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CHARACTERS

OF

MINERALS.

A

TREATISE

ON THE

EXTERNAL,

CHEMICAL, AND PHYSICAL CHARACTERS

OF

MINERALS.

BY

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&c. &c. &c.

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ADVERTISEMENT.

THIS Treatise contains a full account of the various External, Chemical, and Physical Characters employed in the descriptions of Minerals in my System of Mineralogy. It embraces not only the terminology of WERNER, and other German naturalists, but also that of the celebrated HAUY; and to assist the Student, I have given, along with the English terms, also the German, French and Latin

The history of this branch of Mineralogy from the time of AGRICOLA, who published the first systematic arrangement of the Characters of Minerals, to that of the more perfect methods of WERNER and HAUY, would afford an opportunity of communicating much curious information; but it is so extensive, that we must abandon it for the present, and rest satisfied with the following enumeration of the authors who have treated on this subject:

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ON THE

CHARACTERS OF MINERALS.

THE characters of minerals are of different kinds, viz. *External, Chemical, Physical, Geognostical,* and *Geographical.*

1. *External Characters,*—are those which we discover by means of our senses, in the aggregation of minerals, and which have no reference to their relation to other bodies, or to chemical investigations.

2. *Chemical Characters,*—are those which are afforded by the complete analysis of the mineral, by trials with the various re-agents, the blowpipe, and the pyrometer.

3. *Physical Characters,*—are those physical phenomena which are exhibited by the mutual action of minerals and other bodies; such are the magnetic and electric properties exhibited by some minerals.

4. *Geognostical Characters,*—are those derived from various geognostic relations of minerals.

5. *Geographical Characters,*—are derived from the geographical distribution of minerals.

We shall first consider the External Characters, and then the others, in the order already mentioned.

External Characters of Minerals.

The External Characters of Minerals are either *generic* or *specific*. The Generic Characters are certain properties of minerals used as characters, without any reference to their differences, as colour, lustre, or weight. The differences among these properties form the Specific Characters, as adamantine lustre, and glassy or vitreous lustre. The generic characters are divided into *general* and *particular*: Under the first, are comprehended those that occur in all minerals, whether solid, friable, or fluid: under the second, those which occur only in particular classes of minerals. In the following tabular view, the External Characters are arranged nearly in a natural succession, and in the order in which they are employed in the descriptions of minerals.

A

TABULAR VIEW

OF THE

GENERIC EXTERNAL CHARACTERS

OF

MINERALS.

GENERAL GENERIC EXTERNAL CHARACTERS.

1. Colour.
2. The Cohesion of the Particles, according to which minerals are distinguished into

	Solid,	Friable,	Fluid
	Particular generic characters of Solid minerals.	Particular generic characters of Friable minerals.	Particular generic characters of Fluid minerals.
Characters for the sight. — External aspect.	External shape.	External shape.	
	External surface.		
	External lustre.		The lustre.
Characters for the sight. — Aspect of the fracture.	Lustre of the fracture.	The Lustre.	
	The fracture.	Aspect of the particles.	
	Shape of the fragments.		

		Particular generic characters of Solid minerals.	Particular generic characters of Friable minerals.	Particular generic characters of Fluid min
Characters for the sight.	Aspect of the distinct concretions.	Shape of the distinct concretions.		
		Surface of the distinct concretions.		
		Lustre of the distinct concretions.		Transp cy.
	General aspect	The transparency.		
		The streak.	The soiling.	Fluidit
		The soiling.		
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		The tenacity.		
		The frangibility.	The friability.	
		The flexibility.		
		The adhesion to the tongue.		
For the hearing.		The sound.		

Remaining general generic external characters.

For the touch. 3. The Unctuosity.
4. The Coldness.
5. The Weight.

For the smell. 6. The Smell.

For the taste. 7. The Taste.

TAB

TABULAR VIEW

OF THE

DIFFERENT GENERIC AND SUBORDINATE SPECIFIC EXTERNAL CHARACTERS

OF

MINERALS.

GENERAL GENERIC EXTERNAL CHARACTERS.

I. COLOUR.

1. *The different Chief or Principal Colours and their varieties.*

A. WHITE. Weiss. Blanc. Albus.

a. Snow-white. Schneeweiss. Blanc de neige. Niveo-albus.

b. Reddish-white. Röthlichweiss. Blanc rougeatre. Rubescenti-albus.

c. Yellowish-white. Gelblichweiss. Blanc jaunatre. Flavescenti-albus.

d. Silver-white. Silberweiss. Blanc d'argent. Argenteo-albus.

e. Greyish-white. Graulich-weiss. Blanc grisatre. Canescenti-albus.

f. Greenish-white. Grünlich-weiss. Blanc verdatre. Viridescenti-albus.

g. Milk-white. Milchweiss. Blanc de lait. Lacteo-albus.

h. Tin-white. Zinnweiss. Blanc d'étain. Stanneo-albus.

B. GREY.

B. Grey. Grau. Gris. Griseus.

a. *Lead-grey.* Bleigrau. Gris de plomb. Plumbeo-griseus.

α. *Common-lead grey.* Gemeines bleigrau. Gris de plomb commun.

β. *Fresh lead-grey.* Frisches bleigrau. Gris de plomb fraiche.

γ. *Blackish lead-grey.* Schwärzlich bleigrau. Gris de plomb noiratre.

δ. *Whitish lead-grey.* Weisflich bleigrau. Gris de plomb albatre.

b. *Bluish-grey.* Bläulichgrau. Gris bleuatre. Cærulescenti-griseus.

c. *Pearl-grey.* Perlgrau. Gris de perle. Margaritino-griseus.

d. *Smoke-grey.* Rauchgrau. Gris de fumée. Fumoso-griseus.

e. *Greenish-grey.* Grünlichgrau. Gris verdatre. Viridescenti-griseus.

f. *Yellowish-grey.* Gelblichgrau. Gris jaunatre. Flavescenti-griseus.

g. *Ash-grey.* Aschgrau. Gris de cendre. Cinereo-griseus.

h. *Steel-grey.* Stahlgrau. Gris d'acier. Chalybeo-griseus.

C. Black. Schwarz. Noir. Niger.

a. *Greyish black.* Graulischwarz. Noir grisatre. Canescenti-niger.

b. *Iron black.* Eisenschwarz. Noir de fer. Ferreo-niger.

c. *Velvet black.* Sammet schwarz. Noir de velours. Atro-niger.

d. *Pitch black*, or *brownish black.* Bräunlichschwarz. Noir brunatre. Brunescenti-niger.

e. *Raven black*, or *greenish black.* Rabenschwarz oder grünlich schwarz. Noir verdatre. Viridescenti-niger.

f. *Bluish*

f. Bluish black. Bläulichschwarz. Noir bleuatre. Cœrulescenti-niger.

D. Blue. Blau. Bleu. Cœruleus.

a. Blackish-blue. Schwarzlich blau. Bleu noiratre.

b. Azure-blue. Lazurblau. Bleu d'azur. Azureo-cœruleus.

c. Violet-blue. Veilchenblau. Bleu violet. Violaceo-cœruleus.

d. Lavender-blue. Lavendelblau. Bleu de lavande. Lavendula-cœruleus.

e. Plum-blue: Pflaumenblau. Bleu de prune. Pruneo-cœruleus.

f. Berlin-blue, or *Prussian blue.* Berlinerblau. Bleu de Prusse. Berolino-cœruleus.

g. Indigo-blue. Indigblau. Bleu d'indigo. Indico-cœruleus.

h. Smalt-blue. Schmalteblau. Bleu de smalt. Smaltino-cœruleus.

i. Duck-blue. Entenblau.

k. Sky-blue. Himmelblau. Bleu de ciel. Cœlesti-cœruleus.

E. Green. Grün. Verd. Viridis.

a. Verdigris-green. Spangrün. Verd de gris. Ærugineo-viridis.

b. Celandine-green. Seladongrün. Verd celadon, ou de mer. Celadono-cœruleus.

c. Mountain-green. Berggrün. Verd de montagne. Montano-viridis.

d. Leek-green. Lauchgrün. Verd de poireau ou de prase. Prasino-viridis.

e. Emerald-green. Schmaragdgrün. Verd emeraude. Smaragdino-viridis.

f. Apple-green. Apfelgrün. Verd de pomme. Pomaceo-viridis.

g. Grass

g. Grass green. Grasgrün. Verd de pré. Gramineo-viridis.

h. Blackish green. Schärtzlichgrün. Verd noiratre. Nigrescenti-viridis.

i. Pistachio-green. Pistaziengrün. Verd de pistache. Pistacio-viridis.

k. Asparagus-green. Spargelgrün. Verd d'asperge. Asparago viridis.

l. Olive-green. Olivengrün. Verd d'olive. Olivaceo viridis.

m. Oil-green. Oelgrün. Verd d'huile. Olearioviridis.

n. Siskin-green. Zeisiggrün. Verd serin. Acanthino viridis.

F. Yellow. Gelb. Jaune. Flavus.

a. Sulphur-yellow. Schwefelgelb. Jaune de soufre. Sulphureo-flavus.

b. Brass-yellow. Messinggelb. Jaune de laiton. Orichalceo flavus.

c. Straw-yellow. Strohgelb. Jaune de paille. Stramineo-flavus.

d. Bronze-yellow. Speissgelb. Jaune de bronze. Æneo-flavus.

e. Wax-yellow. Wachsgelb. Jaune de cire. Cereo-flavus.

f. Honey-yellow. Honiggelb. Jaune de miel. Melleo-flavus.

g. Lemon-yellow. Citrongelb. Jaune de citron. Citrino-flavus.

h. Gold-yellow. Goldgelb. Jaune d'or. Aureo-flavus.

i. Ochre-yellow. Ockergelb. Jaune d'ochre. Ochraceo-flavus.

k. Wine-yellow. Weingelb. Jaune de vin. Vineo-flavus.

l. Pea-yellow. Erosengelb.

l. Cream,

l. Cream, or Isabella yellow. Isabelgelb. Jaune isabelle. Isabelino-flavus.

m. Orange yellow. Oraniengelb, oder Pommeranzgelb. Jaune d'orange. Aurantio-flavus.

G. Red. Roth. Rouge. Ruber.

a. Aurora, or morning red. Morgenroth. Rouge d'aurore. Auroreo-ruber.

b. Hyacinth red. Hyazinthroth. Rouge d'hyacinthe ou ponceau. Hyacinthino-ruber.

c. Tile red. Ziegelroth. Rouge de brique. Lateritio-ruber.

d. Scarlet red. Scharlachroth. Rouge ecarlate. Scarlatino-ruber.

e. Blood red. Blutroth. Rouge de sang. Sanguineo-ruber.

f. Copper red. Kupferroth. Rouge de cuivre. Cupreo-ruber.

g. Flesh red. Fleischroth. Rouge de chair. Carneo-ruber.

h. Carmine red. Karminroth. Rouge de carmin. Carmineo-ruber.

i. Cochineal red. Koschenillroth. Rouge de cochenille. Coccineo-ruber.

k. Crimson red. Kermesinroth. Rouge cramoisi. Carmesino-ruber.

l. Rose red. Rosenroth. Rouge rose. Roseo-ruber.

m. Peach-blossom red. Pfirsichbluthroth. Rouge de fleurs de pecher. Persicino ruber.

n. Columbine red. Kolumbinroth. Rouge columbin. Columbino-ruber.

o. Cherry red. Kirschroth. Rouge cerise. Cerasino-ruber.

p. Brownish red. Braunlichroth. Rouge brunatre. Brunescenti-ruber.

H. Brown. Braun. Brun. Brunus.

a. Reddish brown. Röthlichbraun. Brun r
atre. Rubescenti-brunus.

b. Clove brown. Nelkenbraun. Brun de ge
Caryophyllino-brunus.

c. Hair brown. Haarbraun. Brun de ch
Capillari-brunus.

d. Broccoli brown. Kohlbraun. Brun de
Brassicino-brunus.

e. Chesnut brown. Kastanienbraun. Brun d
taigne. Castaneo-brunus.

f. Yellowish brown. Gelblichbraun. Brun jau
Flavescenti-brunus.

g. Pinchbeck brown. Tombackbraun. Brun d
bac. Tombacino-brunus.

h. Wood brown. Holzbraun. Brun de bois.
neo-brunus.

i. Liver brown. Leberbraun. Brun de foie.
tico brunus.

k. Blackish brown. Schwärzlichbraun. Brun
atre. Nigrescenti-brunus.

2. *The Intensity of the Colours.* Die höhe der farben,
tensité des couleurs. Vis colorum.

A. Dark. Dunkel. Foncée. Obscurus.
B. Deep. Hoch. Relevée. Eminens.
C. Light. Lichte. Claire. Clarus.
D. Pale. Blass. Pâle. Pallidus.

3. *The delineations, or patterns, formed by the colours.*
Farbenzeichnung. Desseins de couleurs. Pictu
lorum.

A. Dotted. Punctirt. Pointillé. Punctati.
B. Spotted. Gefleckt. Tacheté. Maculati.
C. Clouded. Gewolkt. Nuagé. Nubiformis.

D. Fl

D. FLAMED. Geflammt. Flambé. Flammei.

E. STRIPED. Gestreift. Rubanné. Fasciati.

a. Straight. Gerade. Zonis rectis.

b. Ring-shaped. Ringförmig. Annulaire. Zonis concentricis notati.

F. VEINED. Geadert. Veiné. Venati.

G. DENDRITIC. Baumförmig. Dendritique. Dendritici.

H. RUINIFORM. Ruinenförmig. Ruiniforme. Ruinæformes.

4. *The tarnished colours.* Angelaufenen farben. Couleurs superficielles. Colores superficiales,—*are distinguished,*

A. *According to their origin.* Enstehung. Origine. Origo.

a. In the bosom of the earth. Sogleich auf der lagerstätte.

b. On the exposition of the recent fracture to the action of the air. Bei oder auf jedesmaligen frsichen bruche.

B. *According to the kind.* Nach der art der farben. D'apres leur variations. Quoad aspectum.

a. Merely simple. Einfache. Simples. Simplices.

α. Grey. Grau.

β. Black. Schwarz.

γ. Brown. Braun.

δ. Reddish. Röthlich.

b. Many party coloured together, (variegated). Mehrere zugleich. Bigarées. Variegati.

α. Pavonine, or Peacock-tail. Pfauenschweifig. Queue de pavon. Pavonaceus.

β. Iridescent, or Rainbow. Regenbogenfarbig. Iris. Iridei.

γ. Columbine, or Pigeon-neck. Taubenhälsig. Gorge de pigeon. Columbinii.

δ. Tempered

4. *Tempered steel coloured.* Gehärtete stahlfarben. Acier trempé. Chalibei.

5. *The play of the colours.* Farbenspiel. Jeu de couleurs. Lusus colorum.

6. *The changeability of the colours.* Die Farbenwandlung. La mutabilité des couleurs. Variatio colorum.

A. *On the surface, (observed by looking in different directions* on *the mineral.)* Auf der oberfläche beim daraufschen. A la surface. In superficie.

B. *Internally, (by looking* through *it*). Inwending beim durchschen. A l'interieur. Intus.

7. *The Iridescence.* Das irisiren. *Observed by*

A. *Looking* on *the mineral.*

B. *Looking* through *it.*

8. *The permanent alteration of the colours.* Die Farbenveränderung. Alteration des couleurs. Mutatio colorum.

II. The Cohesion of the Particles. Die Zusammenhang der Theile. Cohesion. Cohærentia partium.

1. *Solid, in general.* Feste im allgemeinen.

A. *Solid, in a stricter sense.*

B. *Friable.* Zerreibliche.

2. *Fluid.*

The remaining Generic Characters are placed at the conclusion of this Tabular view, that is, immediately after the particular Generic Characters.

PARTICULAR GENERIC EXTERNAL CHARACTERS.

Ist.

PARTICULAR GENERIC EXTERNAL CHARACTERS OF SOLID MINERALS.

I. THE EXTERNAL ASPECT. Das aüssere Ansehen. Aspect externe. Aspectus externus.

I. *The External Shape.* Die aüssere gestalt. Figure ou forme externe. Figura externa.

1. COMMON *external shape.* Gemeine aussere gestalten. Figure commune. Figura externa vulgaris.

A. *Massive.* Derb. Massive. Compactum?

B. *Disseminated.* Eingesprengt. Disseminé. Inspersum.

a. Coarsely. Grob eingesprengt. En grosses parties. Crasse inspersum.

b. Minutely. Klein eingesprengt. En petites parties. Minuscule inspersum.

c. Finely. Fein eingesprengt. En fines parties. Minute inspersum.

C. *In angular pieces.* In eckigen stücken. En morceaux anguleux, ou en cailloux. In frustis angulosis.

a. Sharp-cornered. In frischeckigen stücken. A bords tranchans. Angulis integris.

b. Blunt-cornered. In stumpfeckigen stücken. A bords emoussés. Angulis obseletis.

D. *In grains.* Körnern,—*divided,*

a. With regard to size. Grösse,—*into*

α. Large.

α. *Large.* Graupich. Tres gros. Grandiniformib
β. *Coarse.* In groben körnern. Gros. Grandib
γ. *Small.* In kleinen körnern. Petits. Grandiu
culis.
δ. *Fine.* In feinen körnern. Fins. Minutis.

b. *With regard to the exacter determination of t*
shape.
α. *In angular grains.* In eckigen körnern. Ang
leux. Angulosis.
β. *In flattish grains.* In platten körnern. Applat
Compressis.
γ. *In roundish grains.* In rundlichen körnern. A
rondis. Rotundis.

c. *With regard to connection with other minerals.*
α. *In loose grains.* In losen körnern. En grains is
β. *In imbedded grains.* In eingewachsenen körne
En grains implantés.
γ. *In superimposed grains.* In aufgewachsenen k
nern. En grains surposés.

E. *In plates.* In platten. En lames. In laminis.
a. *In thick plates.* In dicken platten. Epais
Crassis.
b. *In thin plates.* In dünnen platten. Minces.
nuibus.

F. *In membranes or flakes.* Angeflogen. En Couche
perficielle. Superficiale.
a. *Thick.* Dick angeflogen. Epaisse. In membr
crassiusculis.
b. *Thin.* Dünn angeflogen. Mince. In membr
tenuibus.
c. *Very thin.* Zart-angeflogen. Tres mince.
membranis tenuissimis.

2. Particu

2. Particular *external shape.* Besondere aussere gestalten. Formes exterieures imitatives. Figuræ externæ singulares.

A. *Longish.* Längliche. Alongées. Longiusculæ.

a. Dentiform. Zähnig. Dentiforme. Dentiformis.

b. Filiform. Drathförmig. Filiforme. Filiformis.

c. Capillary. Haarförmig. Capillaire. Capillaris.

d. Reticulated. Gestrickt. Tricoté ou en reseau. Retiformis.

e. Dendritic. Baumförmig. Dendritiforme. Dendritica.

f. Coralliform or coralloidal Zackig. Coralliforme. Coralliformis.

g. Stalactitic. Tropfsteinartig. Stalactiforme. Stalactica.

h. Cylindrical. Röhrenförmig. Cylindrique. Tubulosa.

i. Tubiform. Pfeifenröhrig. Tubiforme. Fistulosa.

k. Claviform. Kolbenförmig. Claviforme. Claviformis.

l. Fruticose. Staudenförmig. En buissons. Fruticosa.

B. *Roundish.* Runde. Rondes. Rotundæ.

a. Globular. Kuglich. Globuleuse. Globulosa.

α. Perfect globular or spherical. Sphœrish. Spherique. Sphærica.

β. Imperfect globular. Unvolkommen kuglich. Spherique imperfait.

γ. Ovoidal or eliptical. Elliptisch. Ovoide ou elliptique. Elliptica.

δ Spheroidal. Spheroidisch. Spherique applati ou spheroidal. Sphæroidea.

ε. Amygdaloid. Mandelförmig. Amygdaliforme. Amygdaloidea.

b. Botryoidal.

b. Botryoidal. Traubich. Uviformes. Uvæforı
c. Reniform. Nierförmig. Reniforme. Ren
mis.
d. Tuberose. Knollig. Bulbeux ou tubercul
Tuberosa.
e. Fused-like. Geflossen. Coulée. Liquata vel fi
C. *Flat.* Platte. Plattes. Planæ.
a. Specular. Spieglich. Speculaire ou miroi
Specularis.
b. In leaves. In blättchen. En feuilles *ou* bract
Bracteata.
D. *Cavernous.* Vertiefte. Creuses. Excavata.
a. Cellular. Zellich. Cellulaire. Cellulosa.
α. Straight or angulo-cellular. Geradzellig.
1. *Hexagonal.* Sechsseitig.
2. *Polygonal.* Viellseitig.
β. Circulo-cellular. Rundzellich.
1. *Parallel.* Gleichlaufend.
2. *Spongiform.* Schwamförmig.
3. *Indeterminate.* Unbestimmt.
4. *Double.* Doppelt.
b. Impressed. Mit eindrücken. Avec des i
preintes. Impressa.
a. *With impressions of crystals.*
α. Cubical. Würflichen. Cubiques. Vesti
cubicis.
β. Pyramidal. Piramidalen. Pyramidales. 1
ramidalibus.
γ. Tabular. Tafelartagen. Tabuliformis.
bulæformibus.
b. *With impressions of particular external shape.*
α. Conical. Kegelförmigen. Coniques. Coni
β. Globular. Kuglichen. Spheriques. G
bosis.
γ. Reniform. Nierformig. Reniform.
c. Perfora

c. *Perforated.* Durchlöchert. Criblé. Perforata.
d. *Corroded.* Zerfressen. Carié. Corrosa.
e. *Amorphous.* Ungestaltet. Informe. Monstruosa.
f. *Vesicular.* Blasig. Bulleuse. Bellulosa.

E. *Entangled.* Verworren. Emmelées. Implicata.
a. *Ramose.* Astig. Rameuse. Ramosa.

3. Regular *External Shape, or Crystallization.* Regelmässige aussere Gestalten. Formes exterieures regulières, ou crystallisations. Figuræ externæ regulares seu crystallisationes.

A. *The genuineness.* Die wesentlichkeit. Essentialité. Essentialitas: *according to which, crystals are either,*
a. *True.* Wesentliche. Vrais crystaux. Vera crystallisatio,—*or*
b. *Supposititious.* Aftercrystalle. Pseudo crystaux. Pseudo-crystalli.

B. *The shape.* Die Gestalt. Forme des cristaux. Figura crystallorum.
a. *Which is made up of*
α. *Planes.* Flächen. Faces. Plana.
β. *Edges.* Kanten. Bords. Margines.
γ. *Angles.* Ecken. Angles. Apices, *and*
b. *In which is to be observed,*
α. *The fundamental figure.* Die grundgestalt. Forme principale ou dominante. Figura fundamentalis.
(i.) *The parts of which are,*
1. *Planes, either*
A. *Lateral.* Seitenflächen. Faces laterales. Plana lateralia, *or*
B. *Terminal.* Endflächen. Faces terminales. Plana terminalia.
2. *Edges.* Kanten, *either*

A. *Lateral.* Seitenkanten. Bords latéraux. Margines laterales, *or*

B. *Terminal.* Endkanten. Bords terminaux. Margines terminales, *and*

3. *Angles.* Ecken.

(ii.) *The kinds of fundamental figure, which are*

1. *The icosahedron.* Icosaeder. Icosaedre. Icosaedrum.
2. *The dodecahedron.* Dodecaeder. Dodecaedre. Dodecaedrum.
3. *The hexahedron.* Hexaeder. Exaedre. Hexaedrum.
4. *The prism.* Säule. Prisme. Prisma.
5. *The pyramid.* Pyramide. Pyramide. Pyramis.
6. *The table.* Tafel. Table. Tabula.
7. *The lens.* Linse. Lentille. Lens.

(iii.) *The varieties of each kind of fundamental figure in particular, according to*

1. *Simplicity.* Einfacheit. Simplicité. Simplicitas: *which distinction is, however, confined to the pyramid, occurring either*

A. *Single.* Einfach. Simple. Simplex, *which is either*

a. Erect. Rechts. Droite. Erecta.

b. Inverted. Verkehrt. Renversée. Inversa, *or*

B. *Double.* Doppelt. Double. Duplex,—*and then*

a. The lateral planes of the one pyramid set on the lateral planes of the other, either

α. Streight. Gerade. Droite, *or*

β. Oblique. Schief. Biais, *or*

b. On the lateral edges of the other.

2. *Numbers of the planes; here we have to observe*

A. *The species of the planes.* Art der fläehen. Espece des faces, *as*

a. In

a. *In the prism and pyramid the lateral planes are different, and*

b. *In the tables the terminal planes.*

B. *The number of them, according to which they may be, either*

a. *Trihedral, or three-sided.* Dreisetig. Trilatere.

b. *Tetrahedral, or four-sided.* Vierseitig. Quadrilatere.

c. *Hexahedral, or six-sided.* Sechseitig. Sextilatere.

d. *Octahedral, or eight-sided.* Achtseitig. Octolatere.

3. *Proportional size of the planes to one another.* Verhältniss der flächen in ansehung der grösse zu einander. Grandeur des faces relativement les unes aux autres. Proportio planorum respectu magnitudinis.

A. *Equilateral.* Gleichseitig. Faces egales. Plana æqualis.

B. *With unequal planes.* Ungleichseitig. Faces inegales. Plana inæqualia: *either*

a. *Indeterminately unequal.* Unbestimmt. Irregulierement inegales, *or*

b. *Determinately.* Bestimmt. Regulierement inegales,—*which are*

α. *Alternately broad and narrow.* Abwechselend breitere und schmälere. Alternativement larges et etroites.

β. *Two opposite planes broader.* Zwei gegenüberstehende breitere seitenflächen. Deux faces larges opposées.

γ. *Two opposite planes narrower.* Zwei gegenüberstehende schmälere seitenflächen. Deux faces etroites opposées.

4. *The* DIRECTION *of the faces or the planes.* Richtung flächen. Forme des faces. Directio planorum, *which*

A. *Rectilinear or straight.* Geradflächig. Plane. Recti na, *or*

B. *Curvilinear.* Krummflächig. Courbé. Curviplana.—*Th differ partly by*

a. *The position of the curvature.* Nach der lage der kr mung. Position de la courbure. Situs,—*being*

α. *Concave.* Einwärts gekrümmt. Concave. Conc

β. *Convex.* Auswärts gekrümmt. Convexe. Conve

γ. *Concavo-convex.* Ein und auswärts gekrümmt *and partly by*

b. *The shape.* Nach der gestalt. Espece de courb Figura,—*which is either*

α. *Spherical.* Sphärisch.

β. *Cylindrical.* Cylindrisch.

(1.) *The convexity parallel with the length or bre of the sides.* Die convexität mit den seite chen gleichlaufend,—*or*

(2.) *The convexity parallel with the diagonal.* convexität mit den diagonale gleichlaufend.

γ. *Conical* Conisch. Conique. Conica.

5. *The* ANGLES *under which the planes meet.* Winkeln, u welchen die flächen zusammenstossen. Anglesdes entre elles. Quantitas angulorum:—*these are either*

A. *The lateral edges.* Seitenkantenwinkel. Bords raux. Anguli marginales laterales,—*which ar*

a. *Equiangular.* Gleichwinklich. Equiangles. quales.

b. *Unequiangular.* Verschiedenwinklich. Ineg Diversi: *or*

B.

B. *The terminal edges.* Endkantenwinkel. Bords terminaux. Anguli marginales terminales,—*which are*

a. *Rectangular.* Recht. Rectangules. Recti, *or*

b. *Obliquangular.* Schief, *and this*

α. *Parallel oblique.* Gleichlaufend schief.

β. *Alternate oblique.* Abwechselnd schief.

c. *The summit angle.* Endspitzenwinkel. Angle solide du sommet ou pointe. Anguli apicis,—*which may be*

a. *Uncommonly obtuse.* Ausserst stumpfe oder flache. Extremement obtus.

b. *Very obtuse.* Sehr flach oder stumpfe. Tres obtus.

c. *Obtuse.* Flach oder stumpfe. Obtus.

d. *Rather obtuse.* Ein wenig flach oder stumpf. Un peu obtus.

e. *Rectangular.* Rechtwinklich. Rectangulaire.

f. *Rather acute.* Ein wenig spitzig oder scharf. Un peu pointu.

g. *Acute.* Spitzig oder scharf. Pointu.

h. *Very acute.* Sehr spitzig oder scharf. Tres pointu.

i. *Uncommonly acute.* Aussert scharfe oder spitzig. Extremement aigus.

6. *The* MAGNITUDE *of the angles.* Grosse der winkel. Valeur des angles.

7. PLENITUDE *of the crystals.* Völle des crystalls. Plentitude des cristaux. Plenitudo crystallorum,—*either*

A. *Full.* Voll. Plein. Plenæ.

B. *Excavated at the extremities.* Ausgehölt an den enden. Creusc à l'extremité. Terminis excavatæ.

C. *Hollow.* Hohl. Vuide. Cavæ.

(iv.) *The alterations of the fundamental figure take place by*

I. *The Truncation.* Abstumpfung. Troncature. Truncatura.—*Here we have to consider*

1. *The parts of the truncation.* Die theile der abstumpfung. Parties de la troncature. Partes truncaturæ.—*These are*

A. *The planes of the truncation.* Abstumpfungsflächen. Faces de la troncature. Plana truncaturæ.

B. *The edges of the truncation.* Abstumpfungskanten. Bords de la troncature. Margines truncati.

C. *The angles of the truncation.* Abstumpfungsecken. Angles de la tronc. Apices truncaturæ.

2. *The determination of the truncation.* Die bestimmung der abstumpfung. Determination de la troncature. Determinatio truncaturæ,—*which relates to*

A. *The placing of the truncation, or its situation.* Ort. Place de la troncature. Locus.

a. On the edges. An den kanten. Aux bords. Marginibus.

b. On the angles. An den ecken. Aux coins. Apicibus.

B. *Magnitude of the truncation.* Stärke oder grösse. Grandeur de la troncation. Magnitudo.

a. Deep. Stark. Forte. Multum truncatum.

b. Slight. Schwach. Legere. Parùm truncatum.

C. *The setting on or application of the truncation.* Aufsetzung. Position relative de la troncature. Applicatio planorum.

a. Straight.

a. Straight. Gerade. Droite. Recta applicata.
b. Oblique. Schief. De biais. Obliquè applicata.

D. *The direction of the truncating planes.* Die richtung der abstumpfungs flache. Forme de la troncature. Directio planorum,—*which are*

a. Rectilinear. Geradflächig. Plane. Rectiplana.
b. Curvilinear, or roundeed of. Krumflächig. Courbe. Curviplana.

II. *The Bevelment or Cuneature.* Zuscharfung. Bisellement. Acumen. *Here we have to consider:*

1. *The parts of the bevelment.* Theile der zuschärfung. Parties du bisellement. Partes acuminis. *These are,*

A. *The planes of the bevelment.* Die zuschärfungflächen. Faces. Plana acuminis.

B. *The edges of the bevelment.* Die kanten der zuschärfung. Bords. Margines.

a. The proper edge. Die eigentliche zuschärfungskante. Bord formé par les deux faces du bisellement. Proprii acuminis; *and*

b. The edges formed by the bevelling and lateral planes. Die kanten zwischen den zuschärfungs-und-seiten flächen. Bord formé par les faces du bisellement et les autres. Margines inter planem acuminis et lateralia.

C. *The angles of the bevelment.* Die zuschärfungsecken. Coins. Apicis acuminis.

2. *The determination of the bevelment.* Bestimmung. Determination du bisellement. Determinatio acuminis. *Here we have to observe,*

A. *The situation.* Ort. Place du bisellement. Locus.

a. On the terminal planes. An den endflächen. Aux faces terminales. Planis terminalibus.

b. On

b. On the edges. An den kanten. Aux bords. I
ginibus: *and*

c. On the angles. An den ecken. Aux coins. A
cibus.

B. *The magnitude.* Die stärke. Grandeur du bi
ment. Magnitudo. *According to which, it is e*

a. Deep. Stark. Fort. Multum, *or*

b. Slight. Schwach. Legere. Parvum.

C. *The angle.* Der winkel. Bord propre ou s
simple formé par les faces du bisellement. A
lus acuminis.

a. Obtuse. Flach. Obtus. Obtusus.

b. Rectangular. Rechtwinklich. Rectangulaire. I
angulus.

c. Acute. Scharf. Aigu. Acutus.

D. *The uniformity.* Die fortdauer.

a. Uniform. Ungebrochen.

b. Broken. Gebrochen. Fractus.

α. Once broken. Einmal gebrochen.

β. Twice broken. Zweimal gebrochen.

E. *The application.* Die aufsetzung. Position re
du bisellement. Applicatio.

a. Of the bevelment itself. Die zuschärfung s
Position du bisellement. Acuminis ipsius. I
is either

α. Straight. Gerade. Droit. Recta, *or*

β. Oblique. Schief. De biais. Obliqua.

b. Of the planes. Flächen. Celle des biseaux
norum.

α. On the lateral planes. Auf die seitenfläch
les faces laterales. Ad plana lateralia.

β. On the lateral edges. Sur les bords laterau
margines laterales.

II

'he *Acumination.* Zuspitzung.

[ere *we have to consider,*

The parts of the acumination. Die theile der zuspitzung. Parties du pointement. Partes mucronis : *which are*

A. *Acuminating planes.* Zuspitzunflächen. Faces. Plana.

B. *Edges of the acumination.* Zuspitzungskanten. Bords. Margines, *which are either*

a. Acuminating edges. Die eigentliche zuspitzungskanten. Bords du pointement même.

b. Terminal edges of the acumination. Die endkanten der zuspitzung. Bord terminal du pointement.

c. Edges formed by the acuminating and lateral edges. Die kanten, welche die zuspitzungsflächen mit den seitenflächen machen. Bords que les faces du pointement font avec les autres.

C. *The acuminating angles* Die zuspitzungsecken. Coins du pointement. Apices.

a. The angles between the acuminating planes, and the lateral planes of the fundamental figure.

b. The terminal or summit angle.

?. *The determining the acumination depends on observing,*

A. *The situation of it.* Ort. Place du pointment. Locus, *either*

a. On the angles. An den ecken. Aux coins. Apicibus, *or*

b. On the extremities. An den enden. Aux faces terminales. Terminis.

B. *The acuminating planes.* Die zuspitzunflachen. Faces du pointement. Plana.

α. Their number. Deren anzahl. Leur nombre. Numerus.

 b. Their

b. Their proportional magnitude between themselves. renverhaltnissmässige grösse gegen einander. (deur relative entre elles. Magnitudo mutua.

c. Their shape. Deren gestalt. Leur contour. ra, *either*

α. Determinate. Bestimmt. Regulier. Determina

β. Indeterminate. Unbestimmt. Irreguliere. In minata.

d. Their setting on. Die aufsetzung. Position. / catio, *either*

α. On the lateral planes. Auf den seitenflächen. les faces de la forme simple. Ad plana l lia, *or*

β. On the lateral edges. Auf die seitenkanten. les bords de la forme simple. Ad margin terales.

C. *The summit angle.* Der winkel der zuspitzung. du pointement. Angulus: *which is*

a. Obtuse. Flach. Obtus. Obtusus.

b. Rectangular. Rechtwinklich. Rectangulaire. tus.

c. Acute. Scharfwinklich. Aigu. Acutus.

D. *The magnitude.* Die stärke. Grandeur du pointe Magnitudo: *according to which, crystals are*

a. Deeply acuminated. Stark. Fort. Multum m natum: *or*

b. Slightly acuminated. Schwach. Faible. Parum cronatum.

E. *The termination.* Die endigung. Terminaison du po ment. Terminatio: *as the acumination may t nate*

a. In a point In einen punct. Un point. In punc *or*

b. In a line. En un line. Une ligne. In lineam.

IV.

IV. The *Division* of the Planes.

1. *The number, as into two, three, four, or six compartments.*
2. *The direction of the dividing edges.*
   a. *In the direction of the diagonal.*
   b. *From the middle part of the plane towards the angles and edges.*

V. *Multiplied alterations.* Mehrfachen veränderung der grundgestalt: *which occur in certain crystals, and which are either*

1. *Co-ordinate.* Nebeneinandergesetzt, *or*
2. *Superimposed.* Ubereinandergesetzt.

For the more exactly determining a crystallization, may be adjoined the general determination of its planes; and then

α. *The number of the planes in general, and of each species in particular; and*

β. *The shape of each species of plane, must be given.*

Besides these, in describing a crystallization, the following may be observed and adjoined:

a. *The choice of different modes of describing one and the same crystallization.*

The principal or most essential form of a crystallization will be, however, determined

α. *By the larger planes,*

β. *By the greater regularity,*

γ. *By its most frequent occurrence,*

δ. *By its affinity with the other fuudamental forms of the same fossil.*

ε. *By the suitability and adaptation to the alterations which occur in the crystal suite or crystallization; and*

ζ. *By the greater simplicity.*

b. *The*

b. The transitions which arise from thence,

α. That the new or alterating planes become gradually larger, at the expence of certain previous planes, which are at length wholly obliterated,

β. By alterations taking place in the proportion of the planes between themselves,

γ. By alteration of the angles.

δ. By convexity, and

ε. By aggregation.

c. Obstacles which prevent, or at least render the exact determination of certain crystals, difficult, are occasioned by

α. Their obliquity. Verschobenseyn. L'allongement. Obliquitas planorum et angulorum.

β. Their incorporation. Verwachsenseyn. L'Incorporation dans un fossil. Coalescentia.

γ. Their being broken. Verbrochenseyn. Breches. Ruptura, *and*

δ. Their too great minuteness. Die zu grosse kleinheit. La trop grand petitesse. Nimia parvitas.

C. *The Magnitude of the Crystals.* Die Grösse der Krystallen.

a. With regard to their absolute magnitude, crystals are divided into,

α. Uncommonly large. Ungewöhnlich gross. Extremement grand. Eximiè grandes.

β. Very large. Sehr gross. Tres grand. Pergrandes.

γ. Large. Gross. Grand. Grandes.

δ. Middle sized. Von mittlerer grösse. Moyenne grandeur. Mediocriter grandes.

ε. Small. Klein. Petit. Parvæ.

ζ. Very small. Sehr klein. Tres petit. Minutæ.

η. Microscopic. Ganz klein. Tout petit. Minutissimæ.

b. In

b. In describing the relative magnitude of crystals. Die relative grösse. La grandeur relative,—*the following terms are used:*

(α.) *In describing the prism.*

a. *In regard to length,*

aa. Short or low. Kurz oder niedrig. Court.
bb. Long or high. Lang oder hoch. Long.

b. *In regard to breadth and thickness.*

aa. Broad. Breit. Large.
bb. Acicular. Nadelförmig. Aciculaire.
cc. Capillary. Haarförmig. Capillaire.

(β.) *In describing the pyramid.*

a. *In regard to length.*

aa. Short or low. Kurz oder niedrig. Court.
bb. Long or high. Lang oder hoch. Long.

b. *In regard to breadth and thickness.*

aa. Broad. Breit. Large.
bb. Subulate. Spiessig. Subulé.

(γ.) *In describing the table.*

a. *In regard to length and breadth.*

aa. Longish. Länglich. Long.

b. *In regard to thickness.*

aa. Thick. Dick. Epais.
bb. Thin. Dünn. Mince.

(δ.) *Crystals, in which all the dimensions are alike, are named Tessular.*

D. *The*

D. *The Attachment of the Crystals.* Der zusammenhang der krystallen. Le grouppement ou l'adherence des crystaux entre eux. Aggregatio crystallorum. *According to which they may be either*

a. *Solitary.* Einzeln. Separés. Solitariæ; *and this again*

α. *Loose.* Lose. Isolé ou solitaire. Solutæ.

β. *Imbedded.* Eingewachen. Implanté. Innatæ, *or*

γ. *Superimposed.* Aufgewachsen. Superposé. Adnatæ.

b. *Aggregated.* Zusammengehäuft. Groupes aggregés. Connata, *either*

(α.) *A determinate number growing together in a determinate manner;*

1. *With respect to Number,*

i. *Pair wise, (twin crystals.)* Zwillingscrystalle. Jumeaux. Gemellæ.

ii. *Three together, (triple crystals.)* Drillingscrystalle. Jumeaux triples. Tergeminæ.

iii. *Four together, (quadruple crystals.)* Vierlings crystalle. Crystaux quadruples.

2. *With regard to the manner of their connection.* Zulammenfügung.

i. *Intersecting one another.* Durcheinandergewachsen.

ii. *Penetrating one another.* Ineinandergewachsen.

iii. *Adhering to one another.* Aneinandergewachsen.

(β.) *Many together, but merely simply aggregated.* Einfach zusammengehäuft; *either*

i. *On one another.* Aufeinander. Les uns sur les autres. Superimpositæ.

ii. *Side*

ii. *Side by side.* Aneinander. Les uns à cotés des autres. Adpositæ, *or*

iii. *Promiscuously.* Durcheinander gewachsen. Sans ordre. Decussatæ.

(γ.) *Many together, doubly aggregated.* Mehrere doppelt zusamengehäuft. Plusieurs crystaux doublement aggregés. Plures dupliciter connatæ. *The most remarkable are,*

In longish Crystals.
- i. *Fascicular or scopiform.* Buchelförmig. En faisceau. Fasciculatim.
- ii. *Manipular or sheaf-like.* Garbenförmig.
- iii. *Columnar.* Stangeförmig. En barres.
- iv. *Pyramidal.* Pyramidal. En pyramides. Pyramidaliter.

v. *Bud-like.* Knospenförmig. En boutons. Gemmæformiter.

In tabular Crystals.
- vi. *Rose-like.* Rosenförmig. En rose. Rosæformiter.
- vii. *Amygdaloidal.* Mandelförmig. En amandes. Amygdalorum instar.

In roundish or tessular Crystals.
- viii. *Globular.* Kuglich ou kugelförmig. En boule. Globosè.
- ix. *In rows.* Reihenförmig. En rayes. Ordinatim.

x. *Scalarwise aggregated.* Treppenförmig. en Escalier.

4. EXTRANEOUS

4. Extraneous *external shape.* (Petrifactions.) F
dartge aüssere gestalten; Versteinerungen.

A. *From the Animal Kingdom.*

a. Of quadrupeds. Saugethieren.
b. Of birds. Vögeln.
c. Of amphibious animals. Amphibien.
d. Of fishes. Fischen.
e. Of insects. Insecten.
f. Of shells. Schaalthieren, *as*
* *Univalves.*
i. *Belemnites.*
ii. *Ammonites.*
iii. *Turbinites.*
iv. *Strombites, &c.*
** *Bivalves.*
i. *Chamites.*
ii. *Terebratulites.*
iii. *Mytulites.*
iv. *Gryphites.*
v. *Ostracites, &c.*
*** *Multivalves.*
i. *Balanites, &c.*

g. Of crustaceous animals, as echinites, asterites,
h. Of corals, as madreporites, reteporites, enc
entrochites, &c.

B. *From the Vegetable Kingdom,*
a. Impressions of plants
b. Petrified wood.

II.

II. *The External Surface.* Die aussere oberfläche. La surface exterieure. Superficies externa.

1. *Uneven.* Uneben. Inegale. Inæqualis.
2. *Granulated.* Gekörnt. Granulée. Granata.
3. *Rough.* Rauh. Apre. Aspera.
4. *Smooth.* Glatt. Lisse. Lævis.
5. *Streaked.* Gestreift. Striée. Striata.

A. *Simply streaked.* Einfach gestreift. Simplement striée. Simpliciter striata.

a. Longitudinally. In die queere gestreift. En travers. Latitudinaliter.

b. Transversely. In die lange gestreift.

c. Diagonally. Diagonaliter. Diagonalement. Diagonaliter.

d. Alternately. Abwechselnd gestreift. Rayée. Alternè.

B. *Doubly streaked.* Doppelt gestreift. Doublement striée. Dupliciter striata.

a. Plumiformly. Federartig. En barbes de plumes. Pennatim.

b. Reticularly. Gestrickt gestreift. En tricot. Reticulatim.

6. *Drusy.* Drusig. Drusique. Drusica.

III. *The External Lustre* Der aussere glanz. L'eclat exterieur. Nitor externus.

1. *The intensity of the lustre.* Stärke des glanzes. Intensité ou degrés de l'eclat. Gradus nitoris.

Here we have to determine the following degrees:

A. *Splendent.* Starkglänzend. Tres eclatant. Multum nitens.

B. *Shining.* Glänzend. Eclatant. Nitens.

C. *Glistening.* Wennigglänzend. Peu eclatant rum nitens.

D. *Glimmering.* Schimmernd. Brillant ou tr blant. Micans.

E. *Dull.* Mat. Mat. Nitoris expers.

2. *The sort of lustre.* Art des glanzes. Espece d'e Species nitoris.

A. *Metallic lustre.* Metallischer glanz. Eclat me lique. Nitor metallicus.

B. *Common lustre.* Gemeiner glanz: *which is dis guished into*

a. *Semimetallic.* Halbmetallischer glanz. Demim lique. Semimetallicus.

b. *Adamantine.* Demantglanz. Diamant. Adam tinus.

c. *Pearly.* Perlmutterglanz. Nacre. Margaratin

d. *Resinous.* Fettglanz. Cire ou gras. Cereus.

e. *Vitreous.* Glasglanz. Vitreux. Vitreus.

II. THE ASPECT OF THE FRACTURE. Bruchan sehen. Aspect de la cassure. Aspectus in ternus.

IV. *The Lustre of the Fracture, as in the External Lustre*

V. *The Fracture.* Der bruch. La cassure ou la surface i terieur. Fractura,—*of which are*

1. *The following varieties,*

A. *The compact fracture.* Dichte bruch. Dense. D sa.—*This is*

a. *Splintery.* Splittrich. Ecailleuse. Festucosa

α. *Coarse splintery.* Grobsplittrich. A granc ecailles. Festucis majusculis.

β. *Sm*

β. *Small splintery.* Kleinsplittrich. A petites ecailles. Festucis minusculis.

γ. *Fine splintery.* Fein splittrig. A ecailles fines.

b. *Even.* Eben. Egale ou unie. Æqualis.

c. *Conchoidal.* Muschlich. Concoide. Conchæformis.

α. *With respect to size.* Nach der grösse. D'après la grandeur de concavités. Respectu magnitudinis.

i. *Large conchoidal.* Grossmuschlich. Tres evasé. Grandiuscula.

ii. *Small conchoidal.* Kleinmuschlich. Peu evasé. Minuscula.

β. *With regard to depth.* Nach der tiefe. Profondeur du cavités.

i. *Deep conchoidal.* Tief muschlich. A cavités profondes.

ii. *Flat conchoidal.* Flach muschlich. A cavités plates.

γ. *With regard to perfection,* Nach der auszeichnung. D'aprés la perfection de concavités. Respectu perfectionis.

i. *Perfect conchoidal.* Volkommen muschlich. Parfait. Perfecta.

ii. *Imperfect conchoidal.* Unvolkommen muschlich. Imparfait. Imperfecta.

d. *Uneven.* Uneben. Anguleuse ou inegale. Inæqualis.

α. *Coarse grained.* Von grobem korne. Grandes inegalités. Granograndi.

β. *Small grained.* Von kleinem korne. Petites inegalités. Grano minusculo.

γ. *Fine grained.* Von feinem korne. Fines inegalités. Grano minuto.

e. *Earthy.* Erdig. Terreuse. Terrea.

α. *Coarse earthy.* Groberdig.

β. *Fine earthy.* Feinerdig.

f. *Hackly.* Hakig. Crochu. Hamata.

B. *Split*

B. *Split fracture.* Gespâltener bruch.

(A.) *Fibrous fracture.* Der fasriche bruch. Fibreuse, Fibrosa. *Here we have to observe,*

a. *The thickness of the fibres.* Die stärke der fasern, Epaisseur des fibres. Crassities fibrarum.

α. *Coarse fibrous.* Grobfasrig. Grosses fibres. Fibris crassiusculis.

β. *Delicate fibrous.* Zartfasrig. Minces fibres. Fibris tenuibus.

b. *The direction of the fibres.* Die richtung der fasern. Formes des fibres. Directio fibrarum.

α. *Straight fibrous.* Geradfasrig. Droites fibres. Fibris rectis.

β. *Curved fibrous.* Krummfasrig. Courbes fibres. Fibris curvis.

c. *The position of the fibres.* Die lage der fasern. Position des fibres. Situs.

α. *Parallel fibrous.* Gleichlaufend fasrig. Fibres paralleles. Fibris parallelis.

β. *Diverging fibrous.* Auseinanderlaufend fasrig. Fibres divergentes. Fibris divergentibus.

i. *Stellular.* Sternförmig. En etoilles. Stellatim.

ii. *Fascicular or scopiform.* Buschelförmig. En faisceaux. Fasciculatim.

γ. *Promiscuous.* Unter oder durcheinanderlaufend fasrig. Fibres croisées. Fibris decussatis.

(B.) *The Radiated fracture.* Der strahlich bruch. Rayonnée. Radiata. *Here we have to determine*

a. *The breadth of the rays.* Die breite der strahlen. Largeur des rayons. Latitudo radiorum.

α. U

α. *Uncommonly broad radiated.* Ausserordentlich breitstrahlich. Tres larges. Radiis eximie latis.

β. *Broad radiated.* Breitstrahlich. Larges. Radiis latis.

γ. *Narrow radiated.* Schmalstrahlich. Etroits. Radiis arctis.

b. *The direction of the rays.* Die richtung der strahlen. Forme des rayons. Directio.

α. *Straight radiated.* Geradstrahlich. Droits. Radiis rectis.

β. *Curved radiated.* Krummstrahlich. Courbes. Radiis curvis.

c. *The position of the rays.* Die lage der strahlen. Position des rayons. Situs.

α. *Parallel.* Gleichlaufend. Paralleles. Radiis parallelis.

β. *Diverging.* Auseinanderlaufend. Divergens. Radiis divergentibus.

i. *Stellular.* Sternförmig. En entoilles. Stellatim.

ii. *Fascicular or scopiform.* Buschelförmig. En faisceaux. Fasciculatim.

γ. *Promiscuous.* Untereinanderlaufend. Croisés ou entrelacés. Radiis decussatis.

d. *The passage of the rays, or cleavage.* Der durchgang der strahlen. Direction des rayons.

e. *The aspect of the rays surface.* Das ansehen der strahlichen flächen. Aspect de faces rayonnées.

(c.) *The foliated fracture.* Der blättriche bruch. Feuilletée. Lamellosa.

a. *The size of the folia.* Die grösse der blätter. Grandeur des feuillets. Magnitudo lamellarum.

b. *The*

b. The degree of perfection of the foliated fracture: Die volkommenheit. Perfection de la cassure feuilletée. Perfectio.

α. Highly perfect, or specular splendent. Höchst volkommen oder spiegelflächig blättrich. Tres parfaitement feuilletée. Perfectissime lamellosa.

β. Perfect foliated. Volkommen blättrich, Parfaitement feuilletée. Perfectè lamellosa.

γ. Imperfect foliated. Unvolkommen blättrich. Imparfaitement feuilletée. Imperfectè lamellosa.

δ. Concealed foliated. Vesteckt blättrich. Feuilletée cachée. Confusè lamellosa.

c. The direction of the folia. Richtung. Forme des feuillets. Directio.

α. Plane foliated. Geradblättrich. Droits. Recta.

β. Curved foliated. Krummblättrich. Courbes. Curva.

i. *Spherical.* Sphærisch. Spherique. Sphærica.

ii. *Undulating.* Wellenförmig. Ondulé Undulatim.

iii. *Floriform.* Blumig-blättrich. Palmé. Floriformiter.

iv. *Indeterminate.* Unbestimmt. Indeterminé. Indeterminatæ.

d. The position of the folia. Die lage der blätter. Position des feuillets. Situs.

α. Common foliated. Gemeinblättrich.

β. Scaly foliated. Schuppigblättrich.

e. The aspect of the surface of the folia. Das ansehen der blättrichen fl..che.

α. Smooth. Glatt.

β. Streaked. Gestreift.

f. The

f. The passage of the folia or cleavage. Der durchgang der blætter. Clivage ou direction des feuillets. Meatus lamellarum.

α. The number of the cleavages. Zahl der durchgänge.

i. *Single.* Einfach. Simple. Simplex.

ii. *Two-fold.* Zweifach. Double. Duplex.

iii. *Three-fold.* Dreifach. Triple. Triplex.

iv. *Four-fold.* Vierfach. Quadruple. Quadruplex.

v. *Six-fold.* Sechsfach. Sextuple. Sextuplex.

β. The angle under which these cleavages intersect one another. Durchsneidungs winkel.

γ. The greater or lesser degree of perfection of each cleavage. Die mehr oder mindere vollkommenheit jedes durchganges.

(D.) *The slaty fracture.* Shiefrige bruch. Cassure schisteuse.

a. Thickness. Stärke. L'epaisseur des feuillets.

a. *Thick slaty.* Dickschiefrig. A feuillets epais.

b. *Thin slaty.* Dunnschiefrige. A feuillets minces.

b. Direction. Richtung. La direction des feuillets.

a. *Straight slaty.* Geradschiefrig. A feuillets plats.

b. *Curved slaty.* Krummschiefrig. A feuillets courbes.

aa. *Indeterminate curved slaty.*

bb. *Undulating curved slaty.*

c. Perfection. Volkommenheit. La perfection.

a. *Perfect slaty.* Volkommen schiefrig. Parfaite.

b. *Imperfect slaty.* Unvolkommen schiefrig. Imparfaite.

d Cleavage. Durchgang. Le sens des feuillets.

aa. *Single.* Einfach. Simple.

bb. *Double.* Zweifach. Double.

2. *Where*

2. *Where several fractures occur at the same time, their relative situation must be observed, as*

A. *One including the other; Fracture in the great.* Bruch im grossem; *and in the small,* Bruch im kleinen.

B. *One traversing the other; Longitudinal and transverse fracture.* Langebruch und queerbruch. *Cross fracture.* Queerbruch.

VI. *The Shape of the Fragments.* Die gestalt der bruchstücke. Forme des fragmens. Figura fragmentorum.

1. *Regular fragments.* Regelmässige bruchsücke. Fragmens reguliers. Fragmenta regularia.

A. *Cubic.* Würfliche. Fr. Cubiques. Fr. Cubica.

B. *Rhomboidal.* Rhomboidalische. Fr. Rhomboidaux. Fr. Rhomboidalia.

a. Specular on every side. Auf allen seiten spiegelnd. Toutes les faces miroitantes. Omnibus lateribus micantibus.

b. Specular on four sides. Auf zwei seiten spiegelnd. Deux faces miroitantes. Duobus lateribus micantibus.

C. *Trapezoidal.* Trapezoidische. Fr. Trapzoides. Fr. Trapezoidea.

D. *Three-sided pyramidal, and octahedral.* Dreiseitig pyramidale und octaedrische. Fr. Tetraedres et octaedres. Fr. Pyramidalia et octaedra.

E. *Dodecahedral.* Dodecaedrische. Fr. Dodecaedres. Fr. Dodecaedra.

2. *Irregular*

2. *Irregular fragments.* Unregelmässige bruchstücke. Fr. irreguliers. Fr. irregularia.

A. *Cuneiform.* Keilförmige. Fr. cuneiformes. Fr. cuneiformia.

B. *Splintery.* Splittrige. Fr. esquilleux. Fr. festucæformia.

C. *Tabular.* Scheibenförmige. Fr. en plaques. Fr. orbicularia.

D. *Indeterminate angular.* Unbestimmt eckige. Fr. indeterminés. Fr. indeterminata.

a. Very sharp-edged. Sehr shärfkantige. A bords très aigus. Marginibus peracutis.

b. Sharp-edged. Scharfkantige. A bords aigus. Marginibus acutis.

c. Rather blunt-edged. Ein wenig stumpfkantig. A bords peu aigus. Marginibus parum acutis.

d. Blunt-edged. Stumpfkantig. A bords obtus. Marginibus obtusis.

e. Very blunt-edged. Sehr stumpfkantig. A bords très obtus. Marginibus perobtusis.

II. The aspect of the distinct Concretions. Das absonderungs ansehen. Aspect des pieces separées. Aspectus partium segregatarum.

VII. *The Shape of the Distinct Concretions.* Gestalt der abgesonderten stücke. Forme des pieces separés. Figura partium segregatarum.

1. *Granular distinct Concretions.* Körnige abgesonderte stücke. Grenues. Granulosæ: *which differ*

A. *In shape.* In der gestalt. Diversité des formes des grains. Figura,—*and this in*

a. Round granular. Rundkörnig. Grains arondis. Rotundæ.

α. Spherical. Sphærisch. Spheriques. Sphæricæ.

β. Lenticular. Linsenförmig. Lenticulaires. Lenticulares.

γ. Date-shaped. Dattel-förmig. Dactyliformis.

b. Angulo-granular. Eckigkörnig. Anguleux. Angulares.

α. Common granular. Gemeinkörnig. Ordinaires. Vulgares.

β. Longish granular. Longkörnig. Longues. Longiusculæ.

B. *In magnitude.* In der grösse. Grandeur des pieces separées grenues. Magnitudo.

a. Large granular. Grosskörnig. Tres grandes. Grandes.

b. Coarse granular. Grobkörnig. Grandes. Majusculæ.

c. Fine granular. Feinkörnig. Fines. Minutæ.

2. *Lamellar distinct Concretions.* Schaalig abgesondert stücke. Lamelleuses ou testacées. Testaceæ,—*which differ*

A. *In the direction of the lamellæ.* Richtung. Diversité des formes des lames. Directio.

a. Straight lamellar. Geradschaalig. Planes. Rectæ.

α. Quite straight. Ganz gerad. Entierement planes. Perfectè rectæ, *or*

β. Fortifications-wise bent. Fortificationsartig gebogen schaalig. En zigzag, Instar munimentorum.

b. Curved

b. Curved lamellar. Krummschaalig. Courbes. Curvæ.

α. Indeterminate curved lamellar. Gemein krummschaalig. Indeterminées. Vulgariter.

β. Reniform curved lamellar. Nierförmig gebogen schaalig. En rognons. Reniformiter.

γ. Concentrical curved lamellar. Concentrisch schaalig. Concentriques. Concentricé.

1. *Spherical.* Sphærish. Spheriques. Sphærico-concentricè.

2. *Conical.* Conisch. Coniques. Conico-concentri.

B. *In the thickness.* In der stärke. Epaisseur des lames. Crassities.

a. Very thick lamellar. Sehr dickschaalig. Très epaisses. Crassæ.

b. Thick lamellar. Dickschaalig. Epaisses. Crassiusculæ.

c. Thin lamellar. Dünnschaalig. Minces. Tenues.

d. Very thin lamellar. Sehr dünnchaalig. Très minces. Tenusssimæ.

3. *Columnar distinct Concretions.* Stänglich abgefonderte stücke. Colonnaires. Scapiformes: *which are distinguished*

A. *According to the direction.* Nach der richtung. Contournement des colonnes. Directio, *into*

a. Straight columnar. Geradstänglich. Droites. Rectæ.

b. Curved lamellar. Krummstänglich. Courbés. Curvæ.

B. *With regard to thickness.* Stärke. Epaisseur des colonnes. Crassities, *into*

a. Very

b. In regard to lustre: it remains

a. *Unchanged.* Unverändert. De même eclat.

b. *Is increased in intensity.* Nimmt zu. Donnan de l'eclat.

c. *Is diminished in intensity.* Vermindert. Diminuant de l'eclat.

XII. *The Soiling or Colouring.* Abfarben. Tachure. Tinctura, *by which minerals*

1. *Soil.* Abfärben, *either*

A. *Strongly.* Stark, *or*

B. *Slightly.* Etwas, *or*

2. *Do not soil.* Nichtabfärben.

3. *Write.* Schreibend.

V. Characters for the Touch.

XIII. *The Hardness.* Die härte. Dureté. Durities. *T degrees are*

1. *Hard.* Hart. Dur. Durum.

A. *Resisting the file.* Wird von der feile gar nic angegriffen. Resistant à la lime. Limæ n cedens.

B. *Yielding a little to the file.* Wird wenig angegri fen. Cedant un peu à la lime. Limæ parum c dens.

C. *Yielding to the file.* Wird von der feile stark a gegriffen. Cedant à la lime. Limæ cedens.

2. *Semihard.* Halbhart. Demidure. Semidurum.

3. *Soft.* Weich. Tendre. Molle.

4. *Very soft.* Sehr weich. Très tendre. Mollissimur

XIV. *T.*

XIV. *The Tenacity.* Festigkeit. La ductilité. Ductilitas. *The degrees of which are*

1. *Brittle.* Spröde. Aigre. Fragile.
2. *Sectile or mild.* Milde. Traitable. Lene.
3. *Ductile.* Geschmeidig. Malleable. Ductile.

XV. *The Frangibility.* Der zusammenhalt. La tenacité. Tenacitas.

1. *Very difficultly frangible.* Sehr schwer zerspringbar. Tres tenace. Tenacissimum.
2. *Difficultly frangible.* Schwer zerspringbar. Tenace. Tenax.
3. *Not particularly difficultly frangible,* or *rather easily frangible.* Nicht sonderlich schwer zerspringbar. Peu tenace. Non multum tenax.
4. *Easily frangible.* Leicht zerspringbar. Cassant facilement. Parum tenax.
5. *Very easily frangible.* Sehr leicht zerspringbar. Cassant très facilement. Valdè parum tenax.

XVI. *The Flexibility.* Die biegsamkeit. Flexibilité. Flexibilitas: *according to which minerals are either*

1. *Flexible.* Biegsam. Flexible, *and this either*
   A. *Elastic flexible.* Elastisch biegsam. Elastique. Elasticè, *or*
   B. *Common flexible.* Gemein biegsam. Ordinaire. Vulgariter, *or*
2. *Inflexible.* Unbiegsam. Inflexible. Inflexibile.

XVII. *The Adhesion to the Tongue.* Dans anhängen an der zunge. Le happement a la langue. Adhæsio ad linguam, *the degrees of which are,*

1. *Strongly adhesive.* Stark an der zunge hängend. Happe beaucoup. Fortiter adhæret.

2. *Pretty*

2. *Pretty strongly.* Ziemlich stark. Assez. Mediocriter.
3. *Weakly, or somewhat.* Etwas. Un peu. Aliquantum.
4. *Very weakly, or a little.* Wenig. Tres peu. Parum.
5. *Not at all.* Gar nicht. Pas du tout. Nihil.

VI. Characters for the Hearing. Kenzeichen für das gehör.

XVIII. *The Sound.* Der ton. Son. Sonus. *The different sorts of which occurring in the mineral kingdom, are*

1. *A ringing sound.* Klingen. Tintement. Clangor.
2. *A grating sound.* Rauschen. Bruyement. Strepitus. *And*
3. *A creaking sound.* Knirschen. Crissement. Stridor.

II.

IId.

ICULAR GENERIC EXTERNAL CHARACTERS OF *FRIABLE* INERALS. Besondere generische kennzeichen der zerreiblichen fossilien.

HE External Shape. Aussere gestalt. Figure exterieure. Figura externa. *This is*

1. *Massive.* Derb. Massive. Compactum.
2. *Disseminated.* Eingesprengt. Disseminé. Inspersum.
3. *Thinly coating.* Als dünner überzung. En croute mince. Superinductum.
4. *Spumous.* Schaumartig. En ecume. Spumæforme; *and*
5. *Dendritic.* Baumförmig. Dendritique. Dendriticum.

The Lustre. Glanz. Eclat. Nitor.

1. *The intensity.* Stärke des glanzes. Intensité de l'eclat. Gradus nitoris.

   A. *Glimmering.* Schimmernd. Tremblotant. Micans,
   B. *Dull.* Matt. Mat. Nitoris expers.

2. *The sort.* Art des glanzes. Nature de l'eclat. Species nitoris.

   A. *Common glimmering.* Gemein schimmernd. Ordinaire. Vulgaris.
   B. *Metallic glimmering,* Metallischschimmernd. Metallique. Metallicus.

III. The Aspect of the Particles. Ansehen der thei
L'aspect des parties. Aspectus particularum.

1. *Dusty*. Staubige. Pulverulentes. Pulveriformes.
2. *Scaly*. Schuppige. Ecailleuses. Squamosæ.

IV. The Soiling or Colouring. Abfärben. La ta
Tinctura.

1. *Strongly*. Stark. Beaucoup. Multum tingens.
2. *Slightly*. Wenig. Peu. Parum.

V. The Friability. Zerreiblichkeit. Friabilité. Frial

1. *Loose*. Lose. Incoherant. Non conglutinatæ.
2. *Cohering*. Zusammengebacken. Coherant. Co
natæ.

PARTICULAR GENERIC EXTERNAL CHARACTERS OF *FLUID* MINERALS. BESONDERE GENERISCHE KENNZEICHEN DER FLUSSIGEN FOSSILIEN.

I. THE LUSTRE. Glanz. Eclat. Nitor.

1. *Metallic.* Metallischer. Metallique. Metallicus.
2. *Common.* Gemeiner. Ordinaire. Vulgaris.

II. THE TRANSPARENCY. Durchsichtigkeit. Transparence. Pelluciditas.

1. *Transparent.* Durchsichtig. Diaphane. Diaphanum.
2. *Troubled, or turbid.* Trübe. Troublé. Turbidum.
3. *Opaque.* Undurchsichtig. Opacum.

III. THE FLUIDITY. Flüssigkeit. Fluidité. Fluiditas.

1. *Fluid.* Flüssig. Parfaite. Fluidum.
2. *Viscid.* Zahe. Viscuse. Lentum.

REMAINING GENERAL GENERIC EXTERNAL CHARACTERS. UEBRIGE ALLGEMEINE GENERISCHE AUSSERE KENNZEICHEN.

III. THE UNCTUOSITY. Fettigkeit. Toucher ou gras. Pinguitudo.

Of this we have the following degrees.

1. *Very greasy,* Sehr fett. Fort gras. Pinguissimum.
2. *Greasy.* Fett. Gras. Pingue.
3. *Rather greasy.* Ein wenig fett. Un peu gras. Parum pingue.
4. *Meagre.* Mager. Maigre. Macrum.

V. THE

IV. THE COLDNESS. Kälte. Froid. Frigus.

With respect to which minerals are

1. *Very cold.* Sehr kalt. Tres froid.
2. *Cold.* Kalt. Froid. Frigidum.
3. *Pretty cold.* Ziemlich kalt. Mediocriment froid. Frigidiusculum.
4. *Rather cold.* Wenig kalt. Mediocrement froid. Parum frigidum.

V. THE WEIGHT. Schwere. La pesanteur specifique. Gravitas.

1. *Swimming or supernatant.* Schwimmend. Surnageant. Natans.
2. *Light.* Leichte. Leger. Levis.
3. *Not particnlarly heavy, or rather heavy.* Nicht sonderlich schwer. Mediocrement pesant. Parum gravis.
4. *Heavy.* Schwer. Pésant. Gravis.
5. *Uncommonly heavy.* Ausserordentlich schwer. Tres pesant. Eximiè gravis.

VI. THE SMELL. Geruch. Odeur. Odor.

1. *Spontaneously emitted.* Für sich.
   A. *Bituminous.* Bituminös. Bitumineuse. Bituminosus.
   B. *Faintly sulphureous.* Schwach schweflich. Legerement sulphureuse. Sulphureus.
   C. *Faintly bitter.* Schwach bitterlich. Legerement amer. Subamarus.
2. *Produced by breathing on it.* Nach dem anhauchen. En y portant la vapeur de l'expiration. Adflatu.
   A. *Clay-like smell.* Thonigen geruch. Argilleuse. Argillosus.
3. *Excited by friction.* Durch reibung. Par la frottement. Frictione.

A. *Urinous.*

A. *Urinous.* Urinös. Urineuse. Urinosus.

B. *Sulphureous.* Schweflich. Sulphureuse. Sulphuratus.

C. *Garlick-like, or arsenical.* Knoblauchartig. Ail. Alliaceus.

D. *Empyreumatic.* Empyreumatisch. Empyreume. Empyreumaticus.

THE TASTE. Geschmack. Saveur. Sapor.

he varieties are

1. *Sweetish taste.* Süssalzig. Salée. Dulce salsus.
2. *Sweetish astringent.* Sulszusamenziehend. Adstringente.
3. *Styptic.* Herbe. Acerbe. Stypticus.
4. *Saltly bitter.* Salzigbitter. Salée amere. Salsoamarus.
5. *Saltly cooling.* Salzigkühlend. Salée fraiche. Frigido-salsus.
6. *Alkaline.* Laugenhaft. Alcaline. Lixiviosus.
7. *Urinous.* Urinös. Urineuse. Urinosus.

EXTERNAL

EXTERNAL CHARACTERS

OF

MINERALS.

I.

COLOUR.

begin our description of the External Characters nerals with that of Colour, as it is the character first particularly strikes the eye. It exhibits very ariety, and hence its determination is often attended onsiderable difficulty. Although it is an important eful character, it was but ill understood before the f WERNER, and it is even at present, by some mi-gists, considered as of little or no value. The older logists had no very accurate Nomenclature of Co- and rarely gave any definition of them; hence it hat this character, in their systems, did not afford ctory descriptions. Some modern mineralogists, particularly

particularly those of the French School, use in their descriptions, only single, and often unconnected varieties of colour, which is an erroneous practice; because in describing species, we ought to enumerate all the varieties they exhibit, and in a natural order, so that we may obtain a distinct conception of the arrangement of these varieties into groups or suites that characterise the species. WERNER was early aware of the utility of this character, and, by a careful study of all its appearances and varieties. was enabled to form a system of colours for the discrimination of minerals, in which he established a certain number of fixed or standard colours, to which all the others could be referred, defined the varieties and arranged them according to their resemblance to these standard colours, and placed them in such manner, that the whole colours in the system formed a connected series.

In establishing the fixed or standard colours, he thought he could not do better than adopt those as simple colours, which are considered as such in common life; of these he enumerates eight, which he denominates *chief or principal* colours; they are *white*, *grey*, *black*, *blue*, *green*, *yellow*, *red*, and *brown*. Although several of these colours are physically compound, yet for the purposes of the oryctognost it is convenient to consider them as simple.

WERNER remarks, "I could not here enter into an adoption of the seven colours into which the solar ray is divided by the prism, as principal colours, nor into the distinction of the colours accordingly as they are either simple or compound; nor could I omit white and black, the former being considered as a combination of all colours, and the latter as the mere privation of light or colour; for these are distinctions that pertain to the

"theory

ory of colours among natural philosophers, and can- be well applied in common life, in which black is ked among the colours as well as white and yellow; green, which is mixed, considered as a principal ur, as well as red, which is simple.

n the adoption of the principal colours enumerated ve, I am countenanced by Dr SCHŒFFER, who has ibited them with the exception of the grey, in his tch of a general association of colour, Regensburg, 9. I am, however, justified in adding the grey ur, by observing, that it occurs very frequently in mineral kingdom; that the attempt to bring it un- any one of the other colours would be attended h many difficulties, and that, if we have respect to ominations, it is considered in common life as ac- ly differing from the others."—WERNER's *External cters*, p. 38, 39.

ch of these principal colours contains one which is, gnostically considered, pure or unmixed with any which is called the *characteristic colour:* thus snow- is the characteristic colour of white; ash-grey, of velvet-black, of black; Berlin-blue, of blue; eme- reen, of green; lemon-yellow, of yellow; carmine- f red; and chesnut-brown, of brown.

ving thus established eight characteristic colours, he defined and arranged the most striking subordinate ies.

e definitions were obtained principally by ocular ex- tion, which enables us speedily to detect the differ- lours of which the varieties are composed. In de- the results of this kind of *ocular analysis*, if I may e expression, the predominant component parts are oned first, and the others in the order of their quan-

tity. Thus apple-green is found to be a compound colour, and we discover by comparing it with emerald-green, that it is principally composed of that colour and another, which is greyish-white; we therefore define apple-green to be a colour composed of emerald green and a small portion of greyish-white. The method he followed in arranging the varieties is simple and elegant. He placed together all those varieties which contained the same principal colours in a preponderating quantity, and he arranged them in such a manner, that the transition of the one variety into the other, and of the principal colour into the neighbouring ones, was preserved. To illustrate this by an example. Suppose we have a variety of colour which we wish to refer to its characteristic colour, and also to the variety under which it should be arranged. We first compare it with the principal colours, to discover to which of them it belongs, which in this instance we find to be green. The next step is to discover to which of the varieties of green in the system it can be referred. If, on comparing it with emerald-green, it appears to the eye to be mixed with another colour, we must, by comparison, endeavour to discover what this colour is; if it prove to be *greyish-white*, we immediately refer the variety to *apple-green;* if, in place of *greyish-white*, it is intermixed with *lemon-yellow*, we must consider it *grass-green;* but if it contains neither greyish-white nor lemon-yellow, but a considerable portion of *black*, it forms *blackish-green.* Thus, by mere ocular inspection, any person accustomed to discriminate colours correctly, can ascertain and analyse the different varieties of colour that occur in the mineral kingdom.

The transition of the principal colours and their varieties into each other, he represents by placing the charac-

teristic

teristic colours in the middle of a series of which all the members are connected together by transition, and whose extreme links connect them with the preceding and following principal colours. Thus, emerald-green is placed in the middle of a series, the members of which pass, on the one hand, by increase of the proportion of blue into the next colour-suite, the blue; on the other hand, by the increase of yellow into yellow, siskin-green forming the connecting link with yellow, and verdigris green with blue.

NAMES OF THE COLOURS.

The names of the colours are derived, 1st, From certain bodies in which they most commonly occur, as milk-white, siskin-green, liver-brown; 2d, From metallic substances, as silver-white, iron-black, and gold-yellow; 3d, From names used by painters, as indigo blue, verdigris-green, and azure-blue; 4th, From that colour in the composition which is next in quantity to the principal colour, as bluish-grey, yellowish-brown, &c.; and, 5th, From the names of persons, as Isabella-yellow, now called Cream-yellow.

The principal colours are divided into two series, the one comprehending what WERNER terms *bright colours*, the other *dead colours;* red, green, blue, and yellow belong to the first; and white, grey, black, and brown, to the second.

ARRANGEMENT OF THE COLOURS.

The different characteristic colours and their varieties pass into each other, forming suites of greater or less extent, in which the colours either differ more and more from

from the first member of the series, as they approach the extremity, thus forming *straight series*, or, after reaching a certain point of greatest difference from the first colour, again gradually approach, and at length pass into it; thus forming *circular series*. In this way the eight principal colours pass into each other in the order in which we have already enumerated them, and thus form a straight series. The blue colour, however, after it has passed through green and yellow into red, passes from this latter colour by several intermediate varieties again into blue, thus forming a circular series or group.

In the system of colours, we do not introduce these various subordinate transitions and series, but simply arrange all the colours as they pass into each other, beginning with the white, and ending with the brown. The varieties of most of the different principal colours are so arranged, that their characteristic colour is placed in the middle of the series, and all those varieties that incline to the preceding principal colour, are placed immediately after it; while those that incline to the next or following principal colour immediately precede it. This, however, is not the case with the white and grey colours; therefore the characteristic colours in those series do not stand in the middle; on the contrary, in the white, it is placed at the beginning, and in the grey at the end.

DEFINITIONS

DEFINITIONS OF THE DIFFERENT VARIETIES OF COLOUR.

1. WHITE.

This is the lightest of all the colours; hence the slightest intermixture of other colours becomes perceptible. The white colour occurs principally in earthy and saline minerals, seldom in metalliferous minerals, and very rarely amongst inflammable minerals. The following are the varieties of this colour.

a. Snow-white is the purest white colour, being free of all intermixture, and is the only colour of this suite which has no grey mixed with it. It resembles new-fallen snow. As example of it, we may mention Carrara marble.

b. Reddish-white is composed of snow-white, with a very minute portion of crimson-red and ash-grey. It passes into flesh-red. Examples, porcelain-earth and rose-quartz.

c. Yellowish-white is composed of snow-white, with very little lemon-yellow and ash-grey. It passes on the one side into yellowish-grey, on the other into straw-yellow. Examples, chalk, limestone and semiopal.

d. Silver-white is the colour of native silver, and is distinguished from the preceding by its metallic lustre. Examples, arsenical pyrites and native silver.

e. Greyish-white is snow-white mixed with a little ash-grey. Examples, quartz and limestone.

f. Greenish-white is snow-white mixed with a very little emerald-green and ash-grey. It passes into apple-green. Examples, amianthus, foliated limestone, and amethyst.

g. Milk-

g. *Milk-white* is snow-white mixed with a little Berlin-blue and ash-grey. It passes into smalt-blue. The colour of skimmed milk. Examples, calcedony and common opal.

h. *Tin-white* differs from the preceding colour principally in containing a little more grey, and having the metallic lustre. It passes into pale lead-grey. Examples, native antimony and native mercury.

B. GREY.

This, which is one of the palest colours, is a compound of white and black, so that it forms the link by which these two colours are connected together, and is therefore placed between them. It occurs very frequently in the mineral kingdom. The following are its varieties.

a. *Lead-grey* is composed of light ash-grey with a small portion of blue, and possesses metallic lustre. It contains the following subordinate varieties.

α. *Whitish lead-grey.* It is a very light lead-grey colour, into the composition of which a considerable portion of white enters, and therefore nearly approaches to tin-white. Example, native arsenic on the fresh fracture.

β. *Common lead-grey.* It is the purest lead-grey with a slight intermixture of yellow. Example, common grey antimony-ore.

γ. *Fresh lead grey.* It contains rather more blue than the preceding variety, with a slight tint of red, so that it has what is called a fresh or burning aspect. Examples, galena or lead glance, and molybdena.

δ. *Blackish*

d. *Blackish lead-grey.* Is common lead-grey mixed with a little black. Examples, silver-glance or sulphureted silver, and copper-glance or vitreous copper-ore.

e. *Bluish-grey* is ash-grey mixed with a little blue, or is lead-grey without metallic lustre. Examples, hornstone and limestone.

f. *Pearl-grey* is pale bluish-grey intermixed with a little red. It passes into lavender-blue. Examples, quartz, porcelain jasper, crystallised hornstone, and a very pale variety of pearl.

g. *Smoke-grey* is dark bluish-grey, mixed with a little brown. Examples, flint, and some varieties of fluor-spar.

h. *Greenish-grey* is ash-grey mixed with a little emerald-green, and has sometimes a faint trace of yellow. It passes into mountain-green. Examples, clay-slate, whet-slate, potstone, sometimes mica, prehnite, and cat's-eye.

i. *Yellowish-grey* is ash-grey mixed with lemon-yellow and a minute trace of brown. It sometimes passes into cream-yellow and wood-brown. Examples, calcedony and mica.

j. *Ash-grey* is the characteristic colour. It is a compound of yellowish-white and brownish-black. It is the colour of wood-ashes. It passes on the one hand into greyish-black, on the other into greyish-white, as also into greenish, greyish, and smoke-grey. It seldom occurs pure in the mineral kingdom. Examples, quartz, flint and mica.

k. *Steel-grey* is dark ash-grey with metallic lustre. It is the colour of newly broken steel. Examples, grey copper-ore and native platina.

C. BLACK.

C. BLACK.

It presents fewer varieties than any of the other lours, owing probably to the intermixture lighter colours not being observable in it. T discrimination of its varieties is attended v considerable difficulty, and can only be satis torily accomplished after much practice. T following are its varieties.

a. Greyish-black is velvet-black mixed with ash-gr It passes into ash-grey. Is very distinct in salt.

b. Iron-black is principally distinguished from the p ceding variety by its being rather darker, possessing a metallic lustre. It passes into st grey. Examples, magnetic ironstone and ir mica.

c. Velvet-black is the characteristic colour of this ries. It is the colour of black velvet. Exam obsidian.

d. Pitch-black, or *brownish-black*, is velvet-black m ed with a little yellowish-brown. It passes i blackish-brown. Example, earthy cobalt-oc and mica.

e. Greenish-black, or *raven-black*, is velvet-black m ed with a little greenish-grey. It passes i blackish-green. Example, hornblende.

f. Bluish-black is velvet-black mixed with a li blue. It passes into blackish blue, and app sometimes to contain a slight trace of red. ample, black earthy cobalt-ochre.

D. BL

BLUE.

The characteristic colour, which is Berlin-blue, is placed in the middle of the series, and all those varieties that contain red in their composition, on the one side, and those containing green, on the other. It is rarer among minerals than the preceding; blackish blue connects it with black, sky-blue with green; and it is connected with red by violet-blue and azure blue. The following are its varieties.

a. *Blackish-blue* is Berlin-blue mixed with much black and a trace of red. It passes, on the one side, into bluish black, on the other, into azure-blue. Example, azure copper-ore.

b. *Azure-blue* is Berlin blue mixed with a little red. It is a burning colour. Examples, azure copper-ore, and azure-stone.

c. *Violet-blue* is Berlin blue mixed with much red and very little black. It borders on columbine-red. It is the tint of colour we observe in the violet when it is about to blow. It is the most frequent of the blue colours. Examples, amethyst and fluor-spar.

d. *Lavender-blue* is violet-blue, intermixed with a small portion of grey. It is intermediate between pearl-grey and violet-blue. Examples, lithomarge and porcelain-jasper.

e. *Plum-blue* is Berlin blue, with more red than in violet-blue, and a small portion of brown and black. It passes into cherry-red and broccoli-brown. Example, spinel.

f. Berlin-blue is the purest or characteristic colour the series. Example, sapphire.

g. Smalt-blue is Berlin-blue with much white, an trace of green. It passes into milk-white. occurs in pale-coloured smalt, named Esch and also in blue iron-earth, and earthy azu copper-ore.

h. Duck-blue is a dark blue colour, composed of bl much green, and a little black. Examples, f quently in ceylanite, and in a rare variety of durated talc.

i. Indigo-blue, a deep blue colour, composed of bl with a considerable portion of black and a lit green. Example, blue iron-earth of Eckar berg in Thuringia.

k. Sky-blue is a pale blue colour, composed of b and green, and a little white. It forms the li which connects the blue series with the green. is named Mountain-blue by painters. It is t colour of a clear sky, and hence its name. occurs but rarely in the mineral kingdom. I ample, lenticular ore.

E. GREEN.

The varieties of this colour naturally fall into tw principal suites; in the one of which the bl colour prevails; in the other the yellow; and b tween the two is placed the pure or characteri tic colour, the emerald-green. Although it not a common colour in the mineral kingdom yet it is met with more frequently than the blu In earthy minerals the green colours are gen

ral

rally owing to oxide of iron; and in a few cases to the oxide of chrome; and in very few to oxide of nickel. Green colours also occur in several of the ores of copper.

The following are the varieties of this colour.

a. Verdigris green is emerald-green mixed with much Berlin-blue, and a little white. It is the link which connects the green and blue colours together. Examples, copper green and Siberian felspar.

b. Celandine green is verdigris-green mixed with ash-grey. Examples, green-earth, Siberian and Brazilian beryl.

c. Mountain-green is composed of emerald green, with much blue, and a little yellowish-grey; or verdigris-green with yellowish-grey. It passes into greenish-grey. Examples, beryl, aqua marine topaz, glassy actynolite, common garnet, and hornstone.

d. Leek-green is emerald-green, with bluish-grey and a little brown. It is the Sap-green of painters. In this colour, the blue and yellow colours are in equal proportion, so that neither preponderate. Examples, nephrite, common actynolite, and prase.

e. Emerald-green. The characteristic or pure unmixed green. All the preceding green colours are more or less mixed with blue, and at length pass into it; but the following part of the green series, by the increasing proportion of yellow, at length passes into yellow. Examples, emerald, fibrous

fibrous malachite, copper-mica, and sometin also fluor-spar.

f. *Apple-green* is emerald green mixed with a lit greyish white. It passes into greenish whi Examples, nickel-ochre and chrysoprase.

g. *Grass-green* is emerald green mixed with a lit lemon-yellow. The colour of fresh newly spu grass. Example, uranite.

h. *Blackish-green* is pistachio-green mixed with considerable portion of black. It passes ii greenish-black. Examples, precious serpent and augite.

i. *Pistachio-green* is emerald green mixed with m yellow than in grass-green, and a small port of brown. Examples, chrysolite, and epidote pistacite.

k. *Asparagus green* is pistachio-green mixed wit little greyish-white; or emerald-green mi with yellow and a little brown. It passes i liver-brown. Examples, garnet, oliven-ore beryl.

l. *Olive-green* is grass-green mixed with much bro and a little grey. It passes into liver-bro Examples, common garnet, oliven-ore, pit stone, and epidote or pistacite.

m. *Oil-green* is emerald green mixed with yell brown and grey; or pistachio-green, with mu yellow and light ash-grey. It is the colour fresh vegetable oil. Examples, fuller's-ear beryl and pitch-stone.

n. *Siskin-green* is emerald-green mixed with mu lemon-yellow and a little white. It makes t transiti

transition to the yellow colour. Examples, uran-mica and steatite.

F. YELLOW.

Among the varieties of this species of colour, there are three possessing metallic lustre, viz. brass-yellow, gold-yellow, and bronze-yellow. The characteristic colour is lemon-yellow; which is placed in the middle of the series; the colours which precede it are greenish yellow and those which follow it are reddish-yellow. The one side of the series, by the increase of the green, passes by sulphur-yellow into green; the other, by the increase of red, passes, by means of orange-yellow, into red. It is a frequent colour in the mineral kingdom. The following are its varieties.

a. *Sulphur-yellow* is lemon-yellow mixed with much emerald green and white. It is the colour of native sulphur. Example, native sulphur.

b. *Brass-yellow* differs from the preceding colour principally in having a metallic lustre; it contains a small portion of grey. Example, copper-pyrites.

c. *Straw-yellow* is sulphur-yellow mixed with much greyish-white. It passes into yellowish-white and yellowish grey. Examples, calamine, serpentine, and yellow cobalt-ochre.

d. *Bronze-yellow* is brass-yellow mixed with a little steel-grey, and a minute portion of reddish brown. The colour of bell-metal. Example, iron-pyrites.

e. *Wax-yellow*

c. *Wax-yellow* is composed of lemon-yellow, red brown, and a little ash-grey; or it may be sidered as honey-yellow with greyish white. is the colour of pure unbleached wax. amples, opal and yellow lead-ore.

f. *Honey-yellow* is sulphur-yellow mixed with nut brown. It passes into yellowish br Examples, fluor-spar and beryl.

g. *Lemon-yellow* is the pure unmixed colour. It i colour of ripe lemons. Example, yellow ment.

h. *Gold-yellow* is the preceding colour with me lustre. Example, native gold.

i. *Ochre yellow* is lemon-yellow mixed with a derable quantity of light chesnut brown. passes into yellowish brown. It is a very mon colour among minerals. Examples, y earth and jasper.

k. *Wine-yellow* is lemon-yellow mixed with a portion of red and greyish-white. The col Saxon home-made wine. Examples, Saxon Brazilian topaz.

l. *Cream-yellow* or *Isabella-yellow*. It contains red and grey than the wine-yellow, and a little brown. It passes into flesh-red. amples, bole from Strigau, and compact stone.

m. *Orange-yellow* is lemon-yellow with carmin It is the colour of the ripe orange. Exan streak of red-orpiment, and also uran-ochr

I. RED.

It exhibits more varieties than the other colours, and is very common in the mineral kingdom. The characteristic colour is carmine-red; all the others incline either to yellow or blue; hence there are two principal suites; the first of which contains yellowish-red colours; the second bluish-red colours. The red colours are principally owing to oxides of iron, manganese and cobalt, and combinations of metals with sulphur and arsenic. The following are the varieties.

a. *Aurora* or *morning red* is carmine-red mixed with much lemon-yellow. It passes into orange-yellow. Example, red orpiment.

b. *Hyacinth-red* is carmine-red mixed with lemon-yellow and a minute portion of brown; or aurora-red mixed with a minute portion of brown. It passes into brown. Examples, hyacinth and tile-ore.

c. *Tile-red* is hyacinth-red mixed with greyish-white. It is the colour of tiles or bricks. Examples, porcelain-jasper and zeolite.

d. *Scarlet-red* is carmine-red, mixed with a very little lemon-yellow. It is a well-known colour of much intensity. Example, light-red cinnabar from Wolfstein.

e. *Blood-red* is scarlet-red mixed with a small portion of black. Examples, pyrope and jasper.

f. *Flesh-red* is blood-red mixed with greyish-white. Examples, felspar, calcareous-spar, and straight lamellar-heavy spar.

g. *Copper-red.* It scarcely differs from the preceding

ing variety, but in possessing a metallic lus
Examples, native copper and copper-nickel.

h. Carmine-red is the characteristic colour. Examp
spinel, articularly in thin splinters.

i. Cochineal-red is carmine-red mixed with blui
grey. Examples, dark-red cinnabar and red c
per-ore.

k. Crimson-red is carmine-red mixed with a consid
able portion of blue. Example, oriental ruby

l. Columbine-red is carmine-red, with more blue th
the preceding variety, and, what is characteris
for this colour, a little black. Example, ori
tal garnet.

m. Rose-red is cochineal-red mixed with white.
passes into reddish-white. Examples, red m
ganese-ore and quartz.

n. Peach blossom-red is crimson-red mixed with whi
Example, red cobalt ochre.

o. Cherry-red is crimson-red mixed with a consid
able portion of brownish-black. Examples, s
nel, red antimony-ore, and precious garnet.

p. Brownish-red is blood-red mixed with brown.
passes into brown. Example, clay-ironstone.

H. BROWN.

This, after black, is the darkest colour in the syste
The whole species or suite can be distinguisl
into those which have red, and those wh
have yellow mixed; between these is placed
fundamental colour, the pure unmixed ch
nut-brown, and the last variety, from
quantity of black it contains, connects
brown series with the black. Varieties of t
col

colour occur frequently in the mineral kingdom, particularly among the ores of iron, and the inflammable minerals.

a. *Reddish-brown* is chesnut-brown mixed with a little red and yellow; or chesnut-brown with a small portion of aurora-red. It passes into brownish-red. Example, brown blende from the Hartz.

b. *Clove-brown* is chesnut-brown, mixed cochineal-red, and a little black. It is the colour of the clove. It passes into plum blue and cherry-red. Examples, rock-crystal, brown hematite, and axinite.

c. *Hair-brown* is clove-brown mixed with ash-grey. Example, Cornish tin-ore.

d. *Broccoli-brown* is chesnut-brown mixed with much blue, and a small portion of green and red. It passes into cherry-red and plum-blue. It is a rare colour. Example, zircon.

e. *Chesnut-brown.* Pure brown colour. It is a rare colour. Example, jasper.

f. *Yellowish-brown* is chesnut-brown mixed with a considerable portiou of lemon-yellow. It passes into ochre-yellow. It is one of the most common colours in the mineral kingdom. Examples, iron-flint and jasper.

g. *Pinchbeck-brown* is yellowish-brown with metallic lustre. Rather the colour of tarnished pinchbeck. Example, mica.

h. *Wood-brown* is yellowish-brown mixed with much pale ash-grey. It passes into yellowish-grey. Examples, mountain wood, and bituminous wood.

i. Liver-brown is chesnut-brown mixed with olive-green and ash-grey. It is the colour of boiled, not fresh liver. It passes into olive-green. Example. common jasper.

k. Blackish-brown is chesnut-brown mixed with black. It passes into brownish black. Examples, mineral pitch from Neufchatel, moor-coal, and bituminous wood.

The immense variety of colours that occur in the mineral kingdom, constitute an almost infinite series, to characterise every individual of which is next to impossible. The colours we have already defined, are a few only of the most prominent features of that great and beautiful series, and serve as points of comparison, and as the boundaries between which every occurring colour lies.

From the small number of colours we have defined, and the great variety that occur in minerals, it is evident that the greater number of occurring colours will not correspond exactly with those defined, but will lie between them. It is this circumstance in particular that renders it so difficult to get an acquaintance with colours. To obviate this in some degree, WEBNER uses terms which express correctly certain prominent differences which are to be observed between every two colours. Thus, when one colour approaches slightly to another, it is said to *incline* towards it, (es nährt sich); when it stands in the middle between two colours, it is said to be *intermediate*, (es steht in der mitte); when, on the contrary, it evidently approaches very near to one of the colours, it is said to *fall* or *pass* into it, (es geht iiber).

II.

II. THE INTENSITY OR SHADE OF THE COLOURS.

Each colour can be distinguished according to its relative *intensity*, of which, as expressed in the tabular view, there are four degrees, viz. *dark*, *deep*, *light*, and *pale*. Thus the principal colours can be divided into four classes, according to their degrees of intensity; blue, black, and brown are dark; green and red are deep; yellow and white are light; and grey is pale. But this distinction, as far as regards the principal colours, may be dispensed with, as they have been already sufficiently discriminated by their division into bright and dead; it may therefore be confined to the varieties. Thus, in the blue series, lavender blue is pale; smalt and skye blue, light; Berlin, azure, and violet-blue, deep; and indigo, plum, and blackish-blue are dark colours.

The intensity of the colour of a fossil depends often on its degree of transparency; for the more transparent it is, its colour is the paler; and the more opaque, the colour is the darker. Many transparent minerals have therefore a very pale colour, which has caused some mineralogists to describe them as colourless, which, however, is not the case, as their shade of colour is easily detected by an experienced eye, and it can even be discovered, by comparing the minerals with another, by those who have been little accustomed to such investigations.

The intensity of the lustre has also a considerable effect on the intensity of the colour.

III.

III. THE DELINEATIONS OR PATTERNS FORMED BY THE COLOURS.

The distinctions included under this head depend the shape which the colour assumes. It is on to be observed on simple minerals; therefo those mineralogists who have attempted to co sider it as a character for compound minera have deceived themselves. It belongs in gene to the individual. The following are the diff rent kinds enumerated and described by WE NER.

A. *Dotted.* In this variety dots or small spots irregularly dispersed over a surface which ha different colour from the spots. It occurs fr quently in serpentine, but seldom in other min rals.

B. *Spotted.* If the spots are from a quarter of a inch to an inch in diameter, and the basis ground still visible, it is said to be spotted. is either *round* and *regularly spotted*, or *irr gularly spotted.* The first occurs in clay-slate the second in marble.

C. *Clouded.* Here no basis is to be observed; t boundaries of the colours are not sharply mar ed, and the spots run into each other. It occu in marble and jasper.

D. *Flamed.* When the spots are long and acumin ted, and arranged according to their length, t flamed delineation is formed. It has still a bas It occurs in striped jasper, marble, &c.

E. *Strip*

E. *Striped.* Consists of long and generally parallel stripes that touch each other and fill up the whole mass of the stone, so that it has no ground. It presents two varieties.

a. Straight striped, as in striped jasper and variegated clay.

b. Ring-shaped, occurs in Egyptian jasper.

F. *Veined.* Consists of a number of more or less delicate veins crossing each other in different directions, so that it is sometimes net-like. We can always distinguish a base or ground. Examples, black marble veined with calcareous spar or quartz, jasper and serpentine.

G. *Dendritic.* Represents a stem with branches, on a ground. Examples, steatite and dendritic calcedony.

H. *Ruiniform.* Resembles ruins of buildings. It occurs in Florentine marble, which is from this circumstance called *landscape marble.*

These colour-delineations occur most frequently in marble, jasper, and serpentine, and are characteristic of them. They occur seldom in gypsum, flint, calcedony, &c.

IV.

IV. THE PLAY OF THE COLOURS.

If we look on a mineral which possesses this prope ty, we observe, on turning it slowly, besides its commo colours, many others, which are bright, change ver rapidly, and are distributed in small spots or patche A strong light is required, in order to see this appearan distinctly, and it never occurs in opaque or feebly tran lucent minerals. We observe it in the diamond whe cut, in precious opal, and in the fire marble of Bleyber in Carinthia. It appears to the greatest advantage i sunshine, probably, however, even more beautiful i candle light.

V. THE CHANGEABILITY OF THE COLOURS.

When the surface of a mineral, which is turned in di ferent directions, exhibits, besides its common colour different bright colours, which do not change so rapidl are fewer in number, and occur in larger patches than i the play of the colour, it is said to exhibit what is calle the changeability of the colours.

We distinguish two kinds of this phenomenon.

A. That which is observed by looking in differe positions *on* the mineral, as in Labradore felspa

B. That observed by looking *through* it, as in tl common opal, which shews a milk white colo when we look on its surface, but when held b tween the eye snd the light is wine-yellow.

VI. TH

VI. THE IRIDESCENCE.

en a mineral exhibits the colours of the prism or inbow, arranged in parallel, and sometimes vari- curved layers, it is said to be iridescent. It is to :erved by

Looking *on* the mineral, as in the variety of calcareous spar, called Iceland or duplicating spar, adularia, beryl, &c. and by

Looking *through* it, as in rainbow calcedony.

VII. TARNISHED COLOURS.

ıt this character is of importance, is evident from quent occurrence among minerals, and the attention WERNER has dedicated to its developement.

ıineral is said to be tarnished, when it shews on its ıal surface, or on that of the distinct concretions, colours different from those in its interior or fresh re.

ıe colours are distinguished, according to their ; some minerals shewing them,

In the bosom of the earth, as specular iron ore or iron-glance and radiated grey antimony-ore: o- thers

On the exposure of the recent fracture to the action of the air, as variegated copper-ore, and native arsenic.

In

In those minerals where the tarnish has taken place in the bosom of the earth, no new tarnish takes place on exposure of a fresh fracture to the air.

They are further divided according to their kind. Minerals in whatever manner they receive their tarnish are, *a. Simple*, or *b. Variegated*. When we say a colour is simple, we mean that one colour predominates over the whole surface; variegated, when the surface shews many different colours which are distinct or run into each other.

Of the merely simple tarnished colours we may mention as examples the following:

α. *Grey*,—white cobalt-ore.
β. *Black*,—native arsenic.
γ. *Brown*,—magnetic pyrites.
δ. *Reddish*,—native bismuth.

The variegated or party-coloured, are distinguished according to the intensity of their basis. Of these the following are enumerated in the tabular view.

α. *Pavonine*, or *Peacock-tail tarnish*. This is an assemblage of yellow, green, blue, red, and brown colours, on a yellow ground. The colours are nearly equal in proportion, and are never precisely distinct, but always pass more or less into one another. Example, copper-pyrites.

β. *Iridescent*, or *Rainbow*. In this variety the colours are red, blue, green, and yellow, on a grey-ground. It is more beautiful and brighter than the preceding. The radiated grey antimony-ore of Felsobanya in Hungary, and the specular iron-ore or iron-glance of Elba, are often beautifully iridescent.

γ. *Columbine*

γ. *Columbine* or *pigeon-neck tarnish.* The colours are the same as in the preceding, with this difference, that the tints of colour are paler, and the red predominates. Examples, native bismuth of Schneeberg.

δ. *Tempered-steel tarnish.* It consists of very pale blue, red, green, and very little yellow, on a grey ground. Example, grey cobalt-ore.

VIII. THE PERMANENT ALTERATIONS.

These must not be confounded with the tarnished colours. The tarnish occurs only on the surface; the permanent alteration, on the contrary, proceeds by degrees through the whole mass of the mineral. This change takes place more or less rapidly in different minerals. The colours either become paler, when they are said to *fade*, or they become darker, and pass into other varieties. Thus chrysoprase, rose quartz, and red cobalt-ochre become paler; whereas sky-blue fluor-spar becomes green, pearl-grey corneous silver-ore sometimes changes to brown, and lastly into black, and blue iron-earth changes from white, through different varieties of blue, to indigo-blue.

Utility of Colour, as a Character for discriminating Natural Bodies.

The older, and some of the modern mineralogists, as we have already remarked, in their descriptions of the species of minerals, use only single varieties of colour, without attending to their natural relations; hence, as employed by them, colour is a character of but little value. It was Werner who first made the remark, that single varieties are not characteristic, and that it is only by using the whole range or suite of colour of the mineral, that we are enabled to employ this character with advantage, in the discrimination of the species that occur in the mineral kingdom. Thus, it is not sufficient to say that epidote is green, that beryl is green, or that topaz is yellow; we must mention every variety of colour which these minerals possess, because each species of mineral is characterised by a particular suite or group of colours. Even if different species should exhibit precisely the same group of colours, still the character does not thereby lose of its value and importance, because in the different species, the colour suites would be associated with different groups of external characters.

Although colours are frequently employed by botanists for distinguishing species of plants, particularly in the class Cryptogamia, still they in general hesitate in employing

loying them in the discrimination of plants in the higher ivisions of the system.

It is alleged that the colours of plants change very eadily, particularly when cultivated in our gardens, and iat, therefore, so variable a character, should not be atended to. It is not denied, that the colours of plants equently undergo very considerable changes, when culvated in our gardens; but these domesticated plants re no longer the natural unaltered species, and therefore re not objects of the attention of the systematic botaist. It is also known, that plants even in their natural ituations, owing to disease, experience great changes in heir colours; but these diseased individuals would surey never be taken by the botanist for characteristic exmples of the species. Indeed it is highly probable, that very species of plant in its natural region, has a deerminate colour, or suite of colours. Hence colour may e used as a most interesting character, particularly in hose systems of botany which are termed *natural.*

This character may also be advantageously used in giving orrect ideas of the changes of colour which plants experience by cultivation, or when removed from their natural oil and climate. These changes have probably determinate ranges in each species; thus, some run through certain ed and blue varieties, others through red and yellow, and ome through white, red and grey; and in others, the hange does not extend beyond varieties of one colour. ome colours of the suite or range will be more promiient, more fixed, or more frequent than others; and the xtent of the colour-suites will depend on the degree f change in the situation, soil, and climate of the plant. nteresting coloured maps might be constructed, to shew e general changes in the colour of the vegetable world, from

from the Equator towards the Poles; and the difference of colours in vegetables in the two Hemispheres, and in the Old and New World, might be delineated in a similar manner.

In the animal kingdom, the number of different colours is very great. They often form the most striking feature in the external appearance of the species, and hence have been considered by systematics as affording discriminating characters of much value. The agriculturist, engaged in the breeding of animals, often witnesses striking changes in their colours, and these varieties of colour, either alone, or conjoined with other characters, characterise his different breeds. But here, as in botany, a regular systematic nomenclature of colour is much wanted. To render the character of certain value in botany and zoology, there ought to be established a number of fixed or standard colours, to which all the others could be referred: The varieties should be defined and arranged according to their resemblance to these standard colours; and, lastly, the whole ought to be disposed in a regular and systematic order. The various changeabilities of colour, their patterns or delineations, and other similar varieties of character, ought to be defined and arranged as they are in mineralogy.

The anatomist will find it to his advantage, to use in his descriptions some regular and fixed standard of colours; and in morbid anatomy, in particular, the importance of such an aid will be immediately perceived: Thus, the various changes in the animal system, from the slightest degree of inflammation to complete gangrene, are strikingly marked by the different colours the parts assume. Accurate enumerations of these colours as they occur

occur in single varieties, or in groups, conjoined with descriptions of the changes in form, transparency, lustre, consistency, hardness, structure and weight, observable in the diseased parts, will convey an accurate conception of the diseased part to those who have not an opportunity of seeing it. But to effect this, the anatomist and surgeon must agree on some fixed nomenclature, not only of colour, but also of form, transparency, lustre, consistency, hardness and structure; and a better model cannot be pointed out, than that contrived by WERNER for the description and discrimination of minerals.

Lastly, the chemist will have daily opportunities of experiencing its utility; and the meteorologist, and the hydrographer, by the use of an accurate and standard table of colours, will be enabled, in a much more satisfactory manner than heretofore, to describe the skies, and meteors of different countries, and the numerous varieties of colour that occur in the waters of the ocean, of lakes and rivers.

Many attempts have been made to delineate the different colours that occur in the mineral kingdom, with the view of enabling those who do not possess a mineralogical collection, or who may not be familiar with colours, to know the different varieties mentioned in the description of mineralogists. WIEDEMANN, ESTNER, LUDWIG, and several others, have published tables of this kind; but all of them were deficient, not only in accuracy, but also in durability. Having the good fortune to possess a Colour-Suite of Minerals, made under the eye of WERNER, by my late friend H. MEUDER of Freyberg, and being desirous of making this collection as generally useful as possible, I mentioned my wish to Mr SYME,

Painter

Painter to the Wernerian and Horticultural Societies, who readily undertook to make a delineation of all the varieties in the collection. This he executed with his usual skill and accuracy; adding, at the same time, to the series several other colours, which he has distinguished by appropriate names, and arranged along with those in the Wernerian system. The whole have been published in a series of Tables, in a Treatise *, which ought to be in the hands of every mineralogist, and indeed in the possession of naturalists of every description.

II. THE COHESION OF THE PARTICLES.

What is meant by the cohesion of the particles of a mineral is understood by every one; we shall here, therefore, only define their different states of aggregation.

Minerals are divided into *Fluid* and *Solid*, and the solid into

A. *Solid* in a stricter sense, and

B. *Friable*.

By Solid in a stricter sense, we understand that state of aggregation in which the particles cannot be overcome by the pressure of the finger; and by Friable, that state of coherence which can be overcome by the simple pressure of the finger.

PART I

* "WERNER's Nomenclature of Colours, with Additions, arranged so to render it useful to the Arts and Sciences; with Examples, selected fro well known objects in the Animal, Vegetable and Mineral Kingdoms," P. SYME, &c. Edinburgh, 1814.

PARTICULAR GENERIC EXTERNAL CHARACTERS.

I.

ARTICULAR GENERIC EXTERNAL CHARACTERS OF *SOLID* MINERALS.

CHARACTERS FOR THE SIGHT.

1. *THE EXTERNAL ASPECT.*

THE External Aspect of a mineral is that outline or contour which it has received from nature. Thus, if we have a piece of lead-glance, as it has been found loose, or imbedded in another mineral, we name the surface which it has received from nature, its Aspect. All those characters which we can discover by the eye, on this outline, are denominated the External Aspect of the mineral. They are of three kinds: 1. The External Shape: 2. The External Surface; and, 3. The External Lustre.

1. THE EXTERNAL SHAPE

Is divided into four classes,

1. Common
2. Particular
3. Regular
4. Extraneous

} External Shape.

All of these classes have their subordinate differences, which we shall now describe; and,

1. *Common*

1. *Common External Shape.*

Common External Shapes are those in which the neither a determinate number of planes meeting determinate angles, nor any resemblance to know tural or artificial bodies. As they occur more freq ly than the other shapes, they are named Commo ternal Shapes.

Six different kinds are enumerated by WERNER, are distinguished according to their relative le breadth, and thickness, their relative magnitude, their connections with other minerals. The kind *massive, disseminated, in angular pieces, in grai plates*, and *in membranes.*

A. *Massive*, is that common external shape wh from the size of a hazel-nut to the greatest nitude, and whose dimensions in length, bre and thickness, are nearly alike. It occur bedded in other minerals, and it is interr with them at their line of junction. Exan galena or lead-glance and copper-pyrites.

B. *Disseminated*, is from the size of a hazel-nut it is scarcely visible, and its dimensions in le breadth and thickness are nearly alike. It i bedded, and is intermixed with the inclosin neral at the line of junction. It is divided

a. Coarsely disseminated, which is from the si a hazel-nut to that of a pea. Examples, per-pyrites and brown-spar.

b. Minutely disseminated, from the size of a p that of a millet seed. Example, tin-sto granular quartz.

c. F

c. *Finely disseminated*, from the size of a millet seed until it is scarcely visible. Example, brittle silver-glance in brown-spar.

C. *In angular pieces.* Minerals having an angular shape, in which the length, breadth and thickness are nearly alike, which are found loose, or slightly imbedded, and without any intermixture with the inclosing mineral at the line of junction, and from the size of a hazel-nut and upwards, are said to occur in angular pieces. It is distinguished from the massive by its occurring either loose, or not intermixed with the basis at the line of junction. Of this external shape there are two kinds.

a. *Sharp-cornered*, as in quartz and calcedony.

b. *Blunt-cornered*, as in common opal.

The sharp-cornered occur but rarely; opal sometimes exhibits this form. The blunt-cornered are much more frequent, and are either original, or have been formed by attrition, when they are named *pebbles*, or *rolled pieces*. The original pieces are distinguished by a surface which is pretty smooth and shining, and marked with numerous angles and hollows; while the pebbles or rolled pieces have an even and rough surface, and approach more to the roundish form. Calcedony affords a good example of the first kind, and the rolled pieces of common quartz, rock-crystal and flint, found in the beds of rivers, of the second kind.

D. *In grains.* Minerals which are either loose, or slightly imbedded, not being intermixed with the basis in which they are imbedded, and not larger

than a hazel-nut, are said to occur in grains. This shape is distinguished

a. With regard to size, into

α. *Large*, that is, when they are from the size of a hazel-nut to that of a pea. Examples, meadow-ore and precious garnet.

β. *Coarse*, from the size of a pea to that of a hemp-seed. Example, pyrope.

γ. *Small*, from the size of a hemp-seed to that of a millet-seed. Examples, precious garnet, pyrope and iron-sand.

δ. *Fine*, from the size of a millet-seed until it becomes nearly undistinguishable. Example, platina.

The grains are further distinguishable

b. With regard to the exacter determination of the shape into

α. *Angular grains*, as in iron-sand.

β. *Flattish grains*, as in platina and gold.

γ. *Roundish-grains*, as in pyrope and precious garnet.

c. With regard to connection with other minerals.

α. In loose grains.

β. In imbedded grains.

γ. In superimposed grains.

E. *In plates.* Minerals which occur in external shapes whose length and breadth are great in comparison of their thickness, in which the thickness is not equal throughout, and is so considerable, as to allow the fracture to be distinguished, are said to occur in plates. The maximum thickness of plates

plates is half an inch. According to the degrees of thickness, it is distinguished into

a. *Thick plates*, when they are as thick as the back of a penknife. Example, red silver-ore.

b. *Thin plates.* Where thinner than the preceding. Example, silver-glance, or sulphureted silver-ore.

F. *In membranes* or *flakes.* This shape is distinguished from the former by its thinness, as it never greatly exceeds the thickness of common paper, and the fracture cannot be discriminated. Its different degrees of thickness are,

a. *Thick.* Example, silver-glance or sulphureted silver-ore.

b. *Thin.* Example, iron-pyrites.

c. *Very thin.* Example, copper-pyrites on clay-slate.

2. *Particular External Shape.*

Particular external shapes differ from the common external shapes, in bearing a resemblance to natural or artificial bodies, and in being far more characteristic and varied in their aspect. They are called *particular*, because they are not so common among minerals, as the common external shapes. They are divided into five classes, entitled, *longish*, *roundish*, *flat*, *cavernous*, and *entangled*. Each of these species have their subordinate kinds, which we shall now describe.

A. *Longish Particular External Shapes.*

a. *Dentiform*, adheres by its thick extremity, and becomes gradually thinner, incurvated, and at length terminates in a free point, so that it resembles a canine tooth, whence its name. Its length

length is from a quarter of an inch to a fo
It is one of the rarer kinds of external shap
and is peculiar to certain metals. Exampl
native silver and silver-glance, or sulphuret
silver-ore, and native copper.

b. Filiform, adheres by its thicker extremity, a
terminates by an almost imperceptible dimin
tion of thickness, and is usually curved in diffe
ent directions. It is thinner and longer than t
dentiform. Examples, native silver, silver-glan
or sulphureted silver-ore, native gold, and nati
copper.

c. Capillary. When the filiform becomes longer a
thinner, it forms the capillary. It is generall
much entangled, and sometimes the threads a
so near each other that it passes into the co
pact. Example, native silver.

d. Reticulated is composed of many straight thread
which are sometimes parallel and sometimes me
each other at right angles, and form a net-lik
shape. The whole is a series of minute crystal
and is distinguished from the capillary by i
threads being always straight. Examples, n
tive silver, native copper, and copper nickel.

e. Dendritic. In this external shape we can obser
a trunk, branches, and twigs, which are disti
guished from each other by their thickness, t
trunk being the thickest. It is divided into
gular and *irregular dendritic*: in the first, t
branches are set on the trunk, and the twigs
the branches at right angles, or at angles mo
or less acute, as in native silver; in the seco
the branches proceed from the stem, and t
twi

twigs from the branches irregularly, and the shape is not, as is the case with the regular dendritic, a series of crystals. Examples, native copper and brown hematite.

f. *Coralloidal* or *coralliform.* When two or three branches, having rounded or pointed extremities, proceed from one stem, the coralloidal external shape is formed. There are usually many stems together. From its resemblance to coral, it is denominated coralloidal. The variety of arragonite, called *flos ferri,* is an excellent example of this kind of particular external shape.

g. *Stalactitic.* A mineral is said to possess a stalactitic external shape when it consists of different straight more or less lengthened rods, which are thickest at their attachment, and become narrower at their free extremity, which is rounded or pointed. Examples, calc-sinter, brown hematite, and calcedony.

h. *Cylindrical* consists of long, rounded, straight, imperforated, usually parallel rods, which are attached at both extremities, and are generally thicker at the extremities than the middle. The interstices are either empty, or filled up with another mineral. Examples, galena or lead-glance and brown ironstone.

i. *Tubiform* consists of long, usually single, perforated tubes, which are somewhat longitudinally knotty. Example, calc-sinter.

k. *Claviform* is the reverse of stalactitic; it is composed of club-shaped parallel rods, which adhere by their thin extremities. Example, compact black ironstone.

l. Fruc-

l. Fructicose. This external shape is formed when many branches issue from a common stem and meet together partywise, so that the whole when viewed from above has a fructicose aspect, not unlike the appearance of colewort. Examples, calc-sinter and black ironstone.

II. *Roundish Particular External Shapes.*

a. Globular. Under this, as mentioned in the tabular view, are comprehended,

α. Perfect globular or *spherical*, as in alum-slate and pisiform iron-ore.

β. Imperfect globular, as in calcedony, carnelian, agate, and iron-pyrites.

γ. Ovoidal or *elliptical*. Example, rounded masses of quartz in puddingstone.

δ. Spheroidal. When the spherical is compressed the spheroidal is formed. Examples, Egyptian jasper and calcedony.

ε. Amygdaloidal. When the ovoidal is compressed in the direction of its length the amygdaloidal is formed. Examples, zeolite, calcareous-spar and green earth.

ζ. Botryoidal consists of large segments of small balls, which are regularly heaped together, and have many interstices. It resembles grapes, whence its name. Examples, black ironstone and calcedony.

η. Mammillary consists of small segments of large balls, which are so closely set together that no interstices are formed. Examples, red hematite, calcedony and malachite.

i. Tuberose.

d. *Tuberose.* This shape consists of irregular roundish or longish elevations and depressions. Examples, flint and menilite.

e. *Fused-like,* or *liquiform* *. It consists of numerous very flat roundish elevations, which are generally depressed in the middle. The whole has a rough and glimmering surface, and resembles the surface of slowly cooled metal. It is one of the rarest of the external shapes, and has been hitherto found but in one mineral, that is galena or lead-glance; which variety is found in the mine called Alten Grünen Zweig, situated behind the mining village of Erbisdorf near Freyberg, and in that named Methusalem in the same neighbourhood.

C. *Flat Particular External Shapes.*

a. *Specular* has on one side, seldom on two opposite sides, a straight smooth shining surface. It occurs in veins. Examples, galena or lead-glance, copper-pyrites, red ironstone, and quartz.

b. *In leaves.* In this external shape there are thin leaves, which are either irregularly curved, or are straight, and have throughout the same thickness, It is distinguished from the external shape in membranes by the uniformity of its thickness, by its irregular curvatures, its continuity, (the membranous external shape being often interrupted,) and its usual adherence by one

* The term *liquiform* is used by Mr WEAVER, in his excellent translation of WERNER's Treatise on the External Characters of Minerals.

one extremity, shewing that it is a kind of cry
talline shoot. It occurs frequently in native gol
but seldom in native silver.

D. *Cavernous Particular External Shapes.*

a. *Cellular.* A mineral is said to be cellular, when
is composed of straight or bent tables, whi
cross together in such a manner as to form em
ty spaces or cells.

α. *Straight*, or *angulo-cellular*, in which the tab
are straight. It is divided into

1. *Hexagonal*, as in quartz, and cellular pyri
2. *Polygonal*, as in quartz.

β. *Circulo-cellular*, in which the tables are curv
It is divided into

1. *Parallel*, where the cells are in rows, and
cylindrical shape. Example, quartz.
2. *Spongiform.* In this figure the cells are
lindrical, of equal size, very small, bent
ing near each other, disposed in diffe
directions, and not parallel as in the pre
ing. Example, quartz.
3. *Indeterminate.* In this figure the cells hav
particular shape, and are of different s
Example, compact ironstone.
4. *Double circulo-cellular*, consists of large
cells, whose walls are beset with
smaller ones. Example, quartz.

b. *Impressed.* That is, when a mineral shews
impression of any particular or regular ext
shape of another mineral. It borders on the
lular shape, and is formed when a newer m
ral is deposited over an older, the form of w

it assumes, and retains even after the impressing mineral has been destroyed or removed.

a a. *With impressions of crystals.*

α. *Cubical*, as in quartz or iron-pyrites from fluor-spar.

β. *Pyramidal*, as in hornstone, originating from calcareous spar.

γ. *Tabular*, as in quartz, originating from heavy spar.

b b. *With impressions of particular external shapes.*

α. *Conical*, in native arsenic.

β. *Globular*, in silver-glance or sulphureted silver-ore, from red silver-ore.

γ. *Reniform*, in silver-glance or sulphureted silver-ore, from red silver-ore.

Perforated, consists of long vermicular cavities which occupy but an inconsiderable portion of the mass, and terminate on the surface in small holes. When the holes become very numerous, it passes into spongiform. Example, bog iron-ore.

Corroded. A fossil is said to be corroded when it is traversed with numerous hardly perceptible roundish holes. The volume occupied by the holes is nearly equal to that of the basis. It has the appearance of wood which has been gnawed by insects. Examples, quartz, galena or lead-glance, and silver-glance or sulphureted silver-ore.

Amorphous is composed of numerous roundish and angular parts that form inequalities, between which there are equally irregular hollows. The whole has the appearance as if a number of small balls and

True and supposititious crystals are distinguished from each other by the following characters:

a. True crystals.

α. Are transparent and semitransparent.

β. Their planes are smooth and shining or splendent, or they are regularly streaked.

γ. Their angles and edges are sharp.

δ. They form particular characteristic suites.

b. Supposititious crystals.

α. The planes are never smooth and shining, or regularly streaked; on the contrary, are generally rough and dull.

β. The angles and edges are not so sharp as in true crystals, but are generally somewhat rounded.

γ. They are usually hollow, and their internal surface is drusy.

δ. They are not like true crystals, connected by transitions with other crystals of the same species; Thus the octahedral supposititious crystals of quartz, which originate from fluor-spar, do not belong to the suite of quartz.

ε. Even in their internal structure they are different from true crystals; for they seldom present a fracture inclining to foliated.

The following are well known instances of supposititious crystals.

1. Octahedral crystals of quartz, originating from fluor-spar.
2. Cubic crystals of quartz, from fluor-spar.
3. Flint in double three-sided pyramids, from calcareous-spar.

4. Quartz

4. Quartz in oblique four-sided tables, from heavy-spar.

B. The Shape of Crystals.

The shape of crystals is determined by the number and n of the planes or faces, and the edges and angles ich form the contour or outline *. Amidst the great iety of crystals that occur in the mineral kingdom, re are some simple ones, which are composed of but planes, that do not vary much in shape; and of ers, in which the planes are not only numerous, present great differences in form. These simple ms are nearly allied to the more complex ones, and dually pass into them by a change in the shape of r planes. On this circumstance WERNER has found- a Crystallographic System, remarkable for its simplici- and the ease with which it enables us to acquire di- ct conceptions of the most complicated crystallisa- ns. He considers these simple forms as the basis of others, and names them *Fundamental Figures*. We distinguish in them one, or, at the utmost, two sets planes, which run in two directions, and inclose the stal on all sides. The cube is an example of a funda- ntal figure with one set of planes; the prism, pyramid l table, are examples of fundamental figures with two of planes, which are named *lateral* and *terminal ies*. All those crystals in which we observe many erent sorts of planes, he considers as changed or alter- fundamental figures; and names the other planes ch are generally smaller, and differ from the planes of the

* When the faces are very small, they are named *facets*.

the fundamental figure in direction, and in being furtl removed from the centre of the crystal, *Alterating Plan* We have thus, according to this method, to consid first, *The Fundamental Figures*, and then their *Alte tions* or *Modifications*.

I. The Fundamental Figures.

The fundamental figures, as already mentioned, a composed of one or two sorts of planes. In order to di cover these planes in the altered fundamental figures, have only to conceive the planes that lie nearest t centre of the crystal, and which are generally the large extended on all sides until they join.

In the fundamental figure are observed and attend to, I. *Its Parts.* II. *Its Varieties or Kinds.* III. *T Differences of each Fundamental Figure in Particular.*

I. *Parts of the Fundamental Figure.*

The fundamental figure is composed of *lateral* and *te minal planes*; of *lateral* and *terminal edges*; and of *angl*

1. *Lateral planes* are the greatest planes that bou the smallest exent. *Terminal planes* are tl smallest planes that bound the greatest exte In the prism they form the *bases*, but in the tab they are the smaller planes that surround the tw largest planes.
2. *Lateral edges* are formed by the junction of tw lateral planes, as in the prism and pyramid; b in the table, where the lateral planes do not me the lateral edges are those formed by the me

ir

ing of the lateral planes and the terminal planes; or we say, they are the edges of the lateral faces of the table, so that there are eight lateral edges in a four-sided prism, &c. *Terminal edges* are formed by the junction of lateral and terminal planes, as in the prism and pyramid; or they are those that surround the terminal planes in the prism or the base of the pyramid: they are also formed by the junction of two terminal planes, as in the table *.

3. *Angles.* The point in which three or more planes meet, is called a *solid angle.*

I. *The Varieties or Kinds of the Fundamental Figure.*

Werner admits seven fundamental figures, *viz. icosahedron, dodecahedron, hexahedron, prism, pyramid, table,* d *lens.*

1. *Icosahedron* is a solid having twenty equilateral triangular planes, that meet together under nearly equal obtuse angles; and of twelve angles, so that there are always five planes to form an angle. Fig. 1. Pl. I. It is rare. Example, iron-pyrites.
2. *Dodecahedron* has twelve regular pentagonal planes that meet under equal obtuse angles; and of twenty angles. Fig. 2. Pl. I. It occurs but seldom. Example, iron-pyrites.

3. *Hexahedron*

* The terminal edges in the table are these that measure its thickness.

3. *Hexahedron* is a solid, having of six quadrilateral planes and eight angles. It includes the cube Fig. 3. Pl. I.; and the rhomboid, Fig. 4. Pl. I. which is sometimes considered as a double three-sided pyramid, in which the lateral planes of the one are set on the lateral edges of the other. It is very frequent. Examples, calcareous-spar and fluor-spar.

4. *Prism* has an indeterminate number of quadrangular lateral planes terminated by two equal terminal planes parallel to each other, and having as many sides as the prism has lateral planes. Fig. 6. Pl. I. This is the most frequent of the fundamental figures. Examples, calcareous-spar, rock-crystal, schorl and topaz.

5. *Pyramid* has an indeterminate number of triangular lateral planes converging to a point, and of a base possessing as many sides as the figure has lateral planes. Fig. 12. Pl. I. The terminal point is called the *summit-apex*, and the flat part the *base*. It occurs very often. Examples, calcareous-spar and amethyst.

6. *Table* has two equal and parallel lateral planes, which are very large in comparison of the others, and which are bounded by an indeterminate number of small four-sided terminal planes. Fig. 15. Pl. I. It is but a very short prism. It is proper to observe, that the parts of the table are not denominated as those in the prism, but inversely, the lateral planes of the table corresponding to the terminal planes of the prism, and the terminal planes of the table to the lateral planes of the

the prism. It does not occur very often. Examples, heavy-spar and calcareous spar.

7. *Lens* has two curved faces or planes. Fig. 19. and 20. Pl. I. It occurs but seldom. Example, sparry ironstone.

III. *The Differences of each Fundamental Figure in particular.*

Here we have to determine, 1. *The simplicity.* 2. *Number of Planes.* 3. *Proportional size of the planes to one another.* 4. *Direction of the Planes.* 5. *Angles under which the planes meet.* 6. *Plenitude, or fulness of the crystals.*

1. *Simplicity.*

With respect to simplicity, the fundamental figures are either *simple* or *double.* This distinction, however, is confined to the pyramid, as the other six kinds of primitive figures occur simple only. Fig. 12. Pl. I. is a simple pyramid; and Fig. 13. Pl. I. a double pyramid.

The simple figure is also distinguished, in regard of its position, into *erect* or *inverted*, according as it adheres by its base or its summit. The inverted has hitherto occurred only in calcareous-spar, and is very rare.

In the double figure we have to attend to the placing of the lateral planes; thus the lateral planes of the one pyramid are placed either *straight* or *oblique* on the lateral planes of the other pyramid. In Fig. 13. Pl. I. they are placed straight; and in Fig. 14. Pl. I. they are placed obliquely; or the lateral planes of the one pyramid are

set either on the lateral edges, as in Fig. 35. Pl. II. or on the lateral planes of the other, as in Fig. 13. Pl. I.

2. *Number of Planes.*

The number of planes in the icosahedron, dodecahedron, hexahedron, and lens, is always determinate, but in the prism, pyramid, and table, is indeterminate. In the prism and pyramid, it is only the lateral planes that vary in number, but in the table it is the terminal planes.

The *prism* occurs with two, three, four, six, eight, nine, and twelve lateral planes. The trihedral or three-sided occurs in schorl and tourmaline. The four-sided or tetrahedral prism, Fig. 5. Pl. I. occurs very often; we have examples of it in felspar, zeolite, zircon, and heavy-spar. The six-sided or hexahedral prism, Fig. 8. Pl I. occurs very often, and is the most common prismatic crystallization; quartz, emerald, beryl, calcareous-spar, heavy-spar, and actynolite afford examples of it. The octahedral, or eight-sided prism, is rare; it occurs in augite and topaz. The nine and twelve sided prisms are merely varieties of the preceding figures; the first is formed by the bevelling of the lateral edges of the trihedral prism, the other by the truncation of the lateral edges of the six-sided prism. Beryl affords an example of the twelve-sided, and tourmaline of the nine-sided prism.

The pyramid occurs with three, four, six, and eight sides. The three sided pyramid, Fig. 9. Pl. I. is either single or double; of the single we have examples in grey copper-ore, spinel, copper-pyrites, and many other minerals. Examples of the second occur in calcareous-spar

s in Fig. 10. Pl. I. The four-sided pyramid is the most common, and is always double, Fig. 11. Pl. I.; when it appears single, the one half is either hid in part or altogether in the matrix; diamond, zircon, and fluor-spar, are examples. The six-sided or hexahedral pyramid occurs single, as in Fig. 12. Pl. I. and double, as in Fig. 13. Pl. I. Examples of it occur in sapphire and calcareous-spar, red silver ore, white lead-ore, quartz, and amethyst. The eight sided is always double and acuminated on both extremities by four planes, as in Fig. 35. Pl. II. Examples of it occur in leucite, garnet, and silver-glance or sulphureted silver-ore.

The table has four, six, or eight terminal planes. The *three*-sided tables are mere varieties of some of the other figures. The four-sided table, Fig. 15. Pl. I. occurs frequently, as in heavy-spar, white ore of antimony, and yellow lead-ore. The six-sided table, Fig. 17. Pl. I. occurs still more frequently; we have examples of it in mica, calcareous-spar, heavy-spar, and native gold. The eight sided table occurs in heavy-spar and yellow lead-ore.

3. *Proportional Size of the Planes to one another.*

This character is not of very much importance. The planes are either equilateral or unequal; where they are unequal, they are either indeterminately or determinately unequal. The determinately unequal planes are, as mentioned in the tabular view, α. Alternately broad and narrow; β. With two opposite planes broader; γ. With two opposite planes narrower. We shall illustrate this character by examples drawn from the fundamental figures.

In

In the hexahedron, dodecahedron, and icosahedron, the planes are alike; when any dissimilarity occurs, it is merely accidental, and is therefore indeterminately unequal. The three-sided prism shews only slight indeterminate inequalities. The four-sided prism is not always equilateral; sometimes two opposite planes are broader than the others, when the prism is said to be broad, as in zeolite. The six-sided prism is almost always equilateral; its varieties are generally accidental, excepting the following, which are somewhat characteristic. 1. The two opposite lateral planes broader than the others, as in actynolite and heavy-spar. 2. The planes alternately broader and narrower, as in calcareous-spar. The eight and nine sided prisms afford only accidental or indeterminate varieties, as augite, topaz, and tourmaline.

In the pyramid, sometimes the two opposite planes are larger than the others, when it is said to be broad.

The four-sided table is usually equilateral; it has sometimes, however, two opposite lateral planes longer than the others, as in Fig. 16. Pl. I. The six-sided table is sometimes unequilateral, or two opposite planes are larger than the others, as in Fig. 18. Pl. I.; and the eight-sided table is usually longish.

4. *The Direction of the Planes or Faces.*

The direction of the planes or faces is either *Rectilinear* or *Curvilinear*.

Rectilinear is the most common, and is the case with almost all the fundamental figures.

Curvilinear

Curvilinear planes * differ partly by the *position* of the curvature, which is either *concave*, as in fluor-spar; *convex*, as in diamond; *concavo-convex*, as in sparry ironstone; *saddle-shaped*, as in the lens; they differ also by the *shape*, being either *spherical*, as in brown-spar; *cylindrical*, in which the convexity is either parallel with the sides, as in iron-pyrites, or parallel with the diagonal, as in fluor-spar; and *conical*, as in gypsum, and probably also in galena or lead-glance.

5. *Angles under which the Planes meet.*

The size of the angles formed by the meeting of the planes, is determined either by means of an instrument named *Goniometer* or angle-measurer, or simply by ocular inspection. Several different kinds of goniometer have been contrived. The first invented, and that which is at present most generally used, is represented in Plate VII. It consists of a semicircle of brass, divided into degrees. At its centre C is fixed a pin, upon which slide the two arms AB and GF. The last of these GF, by means of a screw, may be fixed in any position, so that the distance between the end G and the centre, may correspond with the face of the crystal to be measured. The other arm AB is drawn up, till the distance between B and the centre corresponds as nearly as possible with the size of the other face of the crystal. It is then turned round, till the angle of the crystal to be measured, corresponds

* It is not geometrically correct to speak of curved planes; yet, as the term plane is more generally used by mineralogists than face or side, I have not thought it necessary to make any alteration.

corresponds exactly with the angle B c G; the arm then cuts the same circle in the angle which corres with that of the crystal. There is a hinge upon the dle of the brass semicircle which is not seen in the fi By means of it, one-half of the semicircle may be th back, when the crystal to be examined happens to situated, in a group, that the arms could not othe come at it. This is the goniometer used by Ro LISLE, HAUY, BOURNON, BERNARDI, WEISS, and crystallographers, and which is sufficiently accurate f general practice of mineralogy. Doctors WOLLASTO BREWSTER have each published descriptions and fi of goniometers, contrived on optical principles, an ceptible of greater accuracy, than the instrument al described. Dr WOLLASTON's instrument is drawn an scribed in the *Philosophical Transactions* for p. 11.; and that of Dr BREWSTER in his *Treatise on Philosophical Instruments*, p. 89.

The other mode of determining the magnitude of tals, namely, by ocular inspection, without the aid c goniometer, is that practised by WERNER. In this he determined the whole of the species in the system it is known that it has enabled him to do so wit curacy.

Several different kinds of angles occur in the fi mental figures: these are the *angles of the lateral* *angles of the terminal edges*, and *the summit angles*.

1. The angles formed by the meeting of the l planes, are named *the angles of the lateral* or, to shorten the description, simply, *l* *edges*. Thus we say, acute and obtuse l edges, in place of acute and obtuse angles

ed by the meeting of the lateral planes. The lateral edges are either *equiangular*, or *unequiangular*. In the icosahedron, all the edges are *equiangular*. In the dodecahedron, the edges are *equiangular*. The hexahedron is either *equiangular* and also *rectangular*, or *unequiangular* and *oblique angular*. The rectangular hexahedron is named *cube*; the oblique-angular, *rhomboid*. In the prism, the lateral edges are either *equiangular* or *unequiangular*. The four-sided prism, with unequiangular lateral edges, is denominated an oblique four-sided prism, as Fig. 6. Pl I. In the pyramid, the lateral edges are generally equiangular; seldom unequiangular. The same is the case with the table; when the edges are unequiangular, we say the terminal planes are set obliquely on the lateral planes.

2. The *terminal edges* are either *equiangular* or *unequiangular*. In the prism they are generally equiangular, as in Fig. 6. Pl. I.; and sometimes unequiangular, when we say that the terminal planes are set obliquely on the lateral planes, as in Fig. 7. Pl. I. They are always equiangular in the pyramid. In the table they are as in the lateral edges of the prism.

3. The *summit angle*. It occurs only in the pyramid. It is measured from plane to plane, or from plane to edge. Werner determines it in degrees in the following manner.

a. Extremely acute is from 1° to 30°.

b. Very acute from 30° to 50°. Example, sapphire.

c. Acute from 50° to 70°. Example, calcareous-spar.

d. Rather

d. Rather acute from 70° to 90°. Example, quartz.

e. Rectangular 90°. Example, zircon.

f. Rather obtuse, or rather flat, from 90° to 110°. Example, honeystone.

g. Obtuse or flat from 110° to 130°. Example, calcareous-spar.

h. Very obtuse or very flat from 130° to 150°. Example, tourmaline.

i. Extremely obtuse, or extremely flat, from 150° to 180°.

6. *Plenitude or Fulness of the crystals.*

A. Full, as in almost all crystals.

B. Excavated at the extremities, as in green lead-ore.

C. Hollow. Olive-green-coloured calcareous-spar, from Schemnitz in Hungary, occurs in acute hollow three-sided pyramids.

II. The Alterations on the Fundamental Figure.

These occur on the edges, angles and planes, and are produced by i. *Truncation;* ii. *Bevelment;* iii. *Acumination; and,* iv. *Division of the Planes.*

i. *Truncation.*

When we observe on a fundamental figure, in place of an edge or angle, a small plane, such a plane is denominate a Truncation *.

These

* Werner, in assuming certain fundamental figures, and supposing them variously modified, does not propose to point out the course followed by

These new planes are named *Truncating Planes*, and he edges which they form with the other planes *Trun-ating Edges*.

We have here to observe what relates to the *situation*, *magnitude*, the *setting on* or *position*, and the *direction* of the *truncation*.

a. In regard to the *situation* of the truncation, it is either on the edges or on the angles, and sometimes a few, sometimes all the angles and edges of the figure are truncated. Fig. 21. Pl. II. is a cube truncated on the angles; and Fig. 22. a cube truncated on the edges.

b. In regard to the *magnitude* of the truncation, it is either *deep* or *slight*, according as more or less of the fundamental figure is wanting; and consequently the truncating planes are proportionally greater or smaller.

c. The planes are *set on* either straight or oblique. They are said to be *set on straight*, when they are equally inclined on all the adjacent planes; and *set on obliquely*, when they are not equally inclined on the adjacent planes.

d. The truncating planes in regard to their *direction*, are either *straight* or *curved*. In the latter case, we also say that the edge or angle is *rounded off*.

by nature in their formation. He employs a peculiar descriptive language to convey a conception of their forms, not to explain the order of their construction. When he describes a crystal as truncated on its angles or edges, he knows very well that nature does not begin by making a crystal complete, in order afterwards to truncate it more or less on one or other of its parts, he only expresses by this term the appearance the crystal presents to the eye, thus employing a well known term to express an operation of nature which still remains to us a mystery.

ii. *Bevelment or Cuneature.*

When the edges, terminal planes, or angles, of damental figure are so altered, that we observe in place two smaller converging planes, terminating edge, it is said to be bevelled. These two newer or tional planes are named *bevelling planes*; and the formed by their meeting, the *bevelling edge*. We here, again, to observe the *situation, magnitude, uniformity* and *setting on* of the bevelment.

a. In regard to *situation*, the bevelment is gen on the edges, sometimes on the terminal p and seldomer on the angles. Fig. 23. Pl. a cube bevelled on the edges; Fig. 24. a sided prism, bevelled on the lateral e Fig. 25. a four-sided prism, bevelled on th minal planes, the bevelling planes set on t teral edges; Fig. 26. a table bevelled on th minal planes; and Fig. 27. an octahedro velled on all the angles.

b. In regard to *magnitude* of the bevelment, it ther *deep* or *slight*, according as more or le fundamental figure is wanting.

c. In regard to the *angle*, the bevelment is *obt flat*, or *rectangular*, or *acute angular*.

d. The bevelment in regard to *uniformity*, is e *unbroken*, when it extends in one direction *broken*, when each bevelling plane consists o veral planes,—sometimes of two planes, wh is said to be *once broken*,—and sometimes of planes, when it is said to be *twice broken*.

e. In regard to the *setting on*, we have to atten the *position* and the *direction* of the bevelme

a. In regard to the *position*, the bevelment is either on planes or on edges.

b. The *direction* varies only when the bevelling planes are set on the terminal planes. It is said to be *set on straight* when it is at right angles to the axis of the crystal; and *set on oblique*, when it forms an oblique angle with the axis of the crystal.

iii. *Acumination.*

A fundamental figure is said to be acuminated when, in place of its angles or terminal planes, we find at least three planes which converge into a point, and sometimes, but more rarely, terminate in an edge.

We have here to observe the parts of the acumination; these are,

The acuminating planes.

The edges of the acumination, which are,

The proper acuminating edges, those formed by the meeting of acuminating planes.

The edges which the acuminating planes make with the lateral planes of the fundamental figure.

The terminal edges of the acumination, which are formed by the terminating of the acuminating planes in an edge or line.

The angles of the acumination; which are,

The angles which the acuminating planes form with the lateral planes; and,

The summit angle.

We have to determine in the acumination, its *situation; the number of its planes; proportional magnitude of the planes among themselves;* the *setting on* or *application of the*

the planes; the *angles of the acumination*; its *magnitude* and *termination*.

a. *Its situation* is either on angles, as in Fig. 28. and 29. Pl. II. or on terminal planes, as in Fig. 30. Pl. II.

b. *The number of planes* is three, as in Fig. 33. and 34. Pl. II.; four, as in Fig. 30. Pl. II.; six, as in Fig. 31. Pl. II.; or eight, as in Fig. 35. Pl. II.

c. *The proportional magnitude of the planes among themselves*, is a character of but little importance. They are generally determinately unequal, as in heavy-spar; or undeterminately unequal, as in rock-crystal.

d. *The setting on* or *application of the planes* refers to their position on edges, as in Fig. 29. 32. 34. Pl. II. or planes, as in Fig. 28. 30. 31. and 33. Pl. II. When the planes of an acumination are not set on all the edges or planes of the fundamental figure, but only on the alternate planes or edges, it is said to be *set on alternately*, as in Fig. 33. and 34. Pl. II.; and when the acuminating planes on both extremities of the fundamental figure are set on the same planes or edges, it is said to be [illegible] (rechtsinnig), as in Fig. 31. Pl. II.; but when the planes on opposite ends of the figure are set on different planes or edges, it is said to be [illegible], as in Fig. 33. and 34. Pl. II. The same expressions are applied to alternate [illegible].

e. The [illegible] of the acumination, or the *summit angle*, is either obtuse or flat, as in garnet: rectangular, as in [illegible], or acute, as in calcareous-spar.

f. The [illegible] according to which crystals are [illegible], as in cubic crystals of fluor-spar, whose angles are acuminated with six planes

planes; *slightly acuminated*, as in copper-pyrites or grey copper-ore.

g. The *termination*, according as the acumination ends in a point, which is the usual mode, or in a line or edge, which is less frequent.

In order to form a more distinct idea of truncation, bevelling and acumination, let us take a cube, prism, pyramid, or any other perfect fundamental figure represented in wood, and cut off each of the edges or angles at one stroke, so that in its stead a plane shall appear; this will be Truncation. But if the extreme planes, the edges, or the angles of any of these fundamental figures be cut off with two converging strokes, the one from this side, the other from that, so that two planes arise, which, terminating in a line, shall present an edge; this will be Bevelling. And if the extreme planes or the angles be cut off at several strokes, all converging together, so that more than two plains arise, commonly terminating in a point, we shall obtain Acumination.

iv. *The Division of the Planes.*

Here the number of the planes of the fundamental figure is neither increased, nor is their figure changed, as is the case with all the preceding alterations, but each plane is divided into a greater or lesser number of smaller planes that meet together under very obtuse angles.

The number of compartments into which a plane is divided, is two, three, four, and six.

The dividing edges run either parallel to the diagonal, or from the centre of the plane of the fundamental figure towards the angles, or towards the middle of the central or terminal angles. Of the first we have an example in the dodecahedral garnet; and of the second in grey copper-ore and diamond.

v. *Multiplied*

v. *Multiplied Alterations.*

The various alterations of the fundamental figures just enumerated, occur singly or several together in the same fundamental figure. In the latter case, they are placed either beside each other, when they are said to be *co-ordinate*, or on one another, when they are said to be *superimposed*. The alterations are considered to be co-ordinate, when they occur in *different places* of the same fundamental figure; of this we have an example in fluor-spar, when the cube is bevelled on the edges, and truncated on the angles. They are named *superimposed*, when they occur in the *same part* of the fundamental figure, and when the first alteration is modified by a second, as in a prism which is bevelled on the terminal planes, and truncated on the bevelling edges. Sometimes, as in topaz, three or more superimposed alterations occurring together in the same figure. Crystallisations frequently occur which are so modified, that they may be described in different ways, and referred sometimes to one, sometimes to another fundamental figure. This gives rise to two modes of description, viz. the *representative* and the *derivative*. If a crystal is described as it appears to the eye at first view, without any reference to its relation to other crystallisations of the same mineral, it is said to be described representatively. But if in the description we attend to its relations with the other crystals of the same mineral, and also to its derivation from these, it is described derivatively. Thus, in calcareous-spar, we meet with forms, which, if described derivatively, would be considered as very low six-sided prisms, acuminated

on

on both extremities with three planes, the planes set on the alternate lateral planes; and the summits of the acuminations so deeply truncated, that they touch the unaltered lateral planes in a line. But on a first view this figure presents nothing prismatic; and if ignorant of its origin from the prism already mentioned, we would rather consider it as a flat, double, three-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other, and the summits and the angles on the common basis deeply truncated. In the same manner, many very broad prisms, as in rock-crystal, at first sight appear like tables, but must be considered as prisms, on account of their derivation and other relations.

The derivative mode is the most interesting and useful, and is that which ought to be followed whenever it is possible.

In those cases, however, where the choice of the fundamental figure is optional, and when it is not determined by tracing it from other crystallisations, we give the preference to that figure which enables us to describe the crystal with the greatest facility and accuracy, and in the shortest manner. It is sometimes advantageous, and also facilitates our conception of the crystal, when we unite together in our description both the modes, using the derivative as the principal one. Thus many varieties of the cube and the rhomboid are more clearly expressed, when we describe them as double three-sided pyramids, in which the lateral planes of the one are set on the lateral edges of the other.

The different modes of describing crystals, depend on the transitions that so often occur between them, by which one figure, owing to a succession of modifications, gradually

dually passes into the other. Thus the cube, by the truncation of its angles, passes into the perfect octahedron. At first the truncating planes on the angles of the cube are small, but become gradually larger and larger until they touch each other, when the crystal exhibits a form intermediate between that of the cube and the octahedron. If the truncating planes still increase in size, they become larger than those of the cube, and are now the principal planes of the figure, while those of the cube are alterating planes, and the whole represents an octahedron truncated on the angles. If the original planes of the cube, which now form truncating planes in the angles of the octahedron, become smaller and smaller, and at length entirely disappear, the perfect octahedron is produced.

The modifications that give rise to these transitions are the following.

1. *Alterations taking place in the proportional magnitude of the planes between themselves.*

   Some planes increase in size, while others diminish, and thus one figure is changed into another. When the alternate lateral planes of the octahedron become larger, while the others diminish, a tetrahedron is formed, or the octahedron passes into the tetrahedron.

2. *Alterations in the angles under which the planes meet.* Thus the common dodecahedron, by the increasing obtuseness of its angles, at length passes into the cube.

3. The *convexity* of the faces of the crystals, which is sometimes occasioned by the division of the planes.

A. By

By the newer or alterating planes becoming gradually larger at the expence of the original planes, which are at length totally obliterated.

These changes are produced either by truncation, bevelment, or acumination: the transition of the cube into the octahedron, is an example of the first: the transition of the octahedron into the icosahedron, by the bevelment of the angles of the octahedron, of the second; and the third is exemplified by the transition of the tetrahedron into the rhomboidal or garnet-dodecahedron, by the acumination of each of the angles of the tetrahedron by three planes.

By the aggregation of crystals. Thus six-sided tables heaped on one another form six-sided prisms.

All the crystals that lie between two principal crystals, d form the transition of the one into the other, con tute what is called a *transition-suite.* These vary in tent, and sometimes they form circles, so that the last ember of the suite passes into the first, or they form traight line, and diverge into numerous branches.

Those mineral species that occur crystallised, are gene- lly characterised by a particular suite of crystals, ich does not occur in the other species. There are, wever, mineral species very different from each other their external characters, in which we meet with the me suite of crystals; and still more frequently do we eet with species that exhibit not the whole suite of cry- ls of another species, but a greater or smaller portion it. Thus there is an extensive suite of crystals which tends from the icosahedron, through the dodecahedron,

the cube, and the octahedron, into the tetrahedron, part of which we sometimes meet with in mineral species, but never the whole, only a larger or smaller portion of it.

That member of the suite of crystals of a mineral species, from which all the others originate or proceed, is named the *Fundamental Crystallisation.* In those suites of crystals which form circles, it is often optional which of the figures we assume as the fundamental one; and in those which are disposed in lines, it is sometimes of little importance at which end we begin our description. Still we always select that crystallisation which occurs the most frequently, and the most distinct in the species, and derive all the others from it.

In mineral species the crystals never appear isolated, but form a kind of progression, and pass gradually into each other. It follows from this important and highly interesting fact, that when a few crystals of a species are known, probably all the intermediate members of the series, which can be easily pointed out by crystallography, and which have not been found, may be expected to exist in nature, because the cause which produced the one part of the series may also have formed the others.

C. The Magnitude of Crystals.

This character is useful, not only in the description of varieties, but also in that of species, because in each mineral species the crystals appear to have a determinate range of magnitude. We have here to attend to the *absolute magnitude*, and also to the *relative magnitude* of crystals.

Crystals

Crystals in regard to their *Absolute Magnitude*, are divided into

α. *Uncommonly large*, when the crystal is two feet and upwards in length. The expression intimates that it is rare. Example, rock-crystal.

β. *Very large*, from two feet to six inches in length. Examples, rock-crystal, quartz, beryl, calcareous spar, and felspar.

γ. *Large*, from six inches to two inches in length. It is a very frequent size. Examples, lead-glance, garnet, rock-crystal, &c.

δ. *Middle-sized*, from two inches to half an inch. Examples of this magnitude are common, we shall only mention galena or lead-glance, iron-pyrites, fluor-spar, calcareous-spar, and garnet.

ε. *Small*, from half an inch to the eighth of an inch. Examples, fluor-spar, calcareous-spar, &c.

ζ. *Very small*, from the eighth of an inch in length, until it is so minute as scarcely to be visible to the naked eye. Examples, native silver, grey copper-ore, spinel, &c.

η. *Microscopic*. When crystallised, but the form no longer distinguishable by the naked eye. Examples, gold, galena or lead-glance, &c.

determining the *Relative Magnitude* of crystals, we use the following terms.

α. In the prism.

αα. For the length.

Short or *low*.

Long or *high*.

ββ. For

bb. For the breadth and thickness.

Broad, when the breadth is greater than the thickness.

Acicular or *needle-shaped*, when the prisms are so thin, that the planes are seen with difficulty.

Capillary, when the planes of the crystals are no longer visible.

β. In the pyramid.

aa. For the length.

Short or *low*.

Long or *high*.

bb. For breadth and thickness.

Broad.

Lance-shaped, allied to acicular.

γ. In the table.

aa. For the length and breadth.

Longish, when one dimension of the lateral planes is greater than the others.

bb. For the thickness.

Thick and *thin*.

δ. Crystals in which all the dimensions are nearly alike, are named *tessular*.

D. The

D. The Attachment of Crystals.

ER understands by *attachment*, the connection of ystals with massive minerals, and the aggrega- rystals together. According to the tabular view, distinction is into

litary, and this again into *loose*, *imbedded*, and *superimposed*.

Loose. Crystals are said to be loose, when they are not connected with any other mineral.

Imbedded. Crystals are said to be imbedded, when they are completely inclosed in another mineral. They are crystallised on all sides, or are said to be all around crystallised, and must therefore have been formed at the same time with the mineral in which they are imbedded. We cannot conceive them to have been of anterior origin to the basis in which they are contained; for, on this supposition, we must conceive them to have remained suspended in space until the basis was formed around them. Nor can we admit them to be of posterior origin, because the crystals have impressed their form on the basis, and portions of the basis are sometimes contained in the crystals, and the crystals at their lines of junction, occasionally intermixed with the basis. Examples of this we have in garnets, imbedded in serpentine, or garnets in mica-slate.

Superimposed. When crystals rest upon the surface of another mineral, and are firmly attached to

to it, they are said to be superimposed. No regular planes occur at their point of attachment, on the contrary, they take the impression of the kind of surface on which they rest. Hence it would appear, that probably they are often of posterior origin to the basis on which they rest.

The second distinction is into

B. *Aggregated.* Here there are two distinctions.

a. Where a determinate number of *crystals grow together in a determinate manner, and these differ,*

1. *With respect to number.*

i. *Pair-wise* (twin crystals).

ii. *Three together* (triple crystals).

iii. *Four together,* (quadruple crystals).

2. *With regard to the manner of their intersection.*

i. *Penetrating one another.*

ii. *Intersecting one another.*

iii. *Adhering to one another.*

Twin crystals are formed by two crystals penetrating, intersecting, or adhering to one another. Of the *first* we have an example in felspar, where they penetrate one another in the direction of their thickness; in gypsum, where they penetrate one another in the direction of their breadth; and in calcareous-spar, where they penetrate one another in the direction of their length. Of the *second* we have an example in cross-stone, where

where the crystals intersect each other, and form a kind of cross, and have a common axis; and of the *third* in spinel, where the crystals adhere only by some of their planes.

Triple crystals, occur in spinel and calcareous-spar.

Quadruple crystals, occur rarely, as in tin-stone.

b. Where there are many crystals together, but merely simply aggregated; and these are either, 1. *On one another;* 2. *Side by side*, or adhering laterally to one another; and, 3. *Promiscuous*.

The *first* occurs principally in tessular crystals, as in galena or lead-glance, and calcareous-spar. The *second* occurs in amethyst, where the pyramids or prisms are parallel among themselves. The *third* occurs principally in long and broad figures, as in tables and prisms. We have examples of it in grey ore of antimony, where very long and nearly needle-shaped crystals cross one another in different directions; also in tabular crystals, and this kind of tabular aggregation has much resemblance to the cellular external shape.

c. Where there are many crystals together, but doubly aggregated.

This kind of aggregation is distinguished from the foregoing by its forming groupes that exhibit shapes resembling bodies in common life.

i. *Scopiform* or *fascicular*. Is composed of a number of thin prismatic crystals, diverging from their point of attachment, and thus forming

forming a kind of fasciculus or bundle. Examples, calcareous-spar and zeolite.

ii. *Manipular* or *sheaf-like*. Consists of a number of crystals that diverge towards both ends, and are narrower in the middle, thus resembling a sheaf. It occurs in prismatic and tabular crystals. Examples, zeolite, calcareous-spar, and prehnite.

iii. *Columnar*. Consists of very long needle-shaped prisms, many of which are connected together in the direction of their length; and these columnar groupes sometimes cross one another in different directions. Example, columnar heavy-spar, and white lead-ore.

iv. *Pyramidal*, is composed of many long prismatic crystals that are parallel to one another, but of which those in the middle are the highest, and the others decline on all sides, from the central one. Example, calcareous-spar.

v. *Bud-like*, is composed of low, (generally) six-sided pyramids, one of which is usually situated in the middle, and is surrounded by a number of others, whose extremities are directed towards one another. Here also many groupes occur together. Example, quartz.

vi. *Amygdaloidal*, is formed by tables disposed around each other, in such a manner as to form an amygdaloidal shape. Example, s raight lamellar heavy-spar.

vii. *Rose-like*, is composed of very thin six-sided tables, which are repeatedly curved, and so connected together that it resembles a blown rose. It occurs in the variety of calcareous-spar called *rose-spar*, from Joachimsthal.

viii. *Globular*. Is composed of tables or cubes aggregated into a globular shape. Examples, iron-pyrites, and curved lamellar heavy-spar.

ix. *In rows*. When many crystals are superimposed on each other, in a straight direction, like the pearls in a necklace, they are said to be aggregated in rows. The flat three-sided pyramids of calcareous-spar, and the octahedrons of silver-glance or sulphureted silver-ore, afford examples of this kind of aggregation.

x. *Scalarwise*, in which many tessular crystals are arranged like steps of a stair. Example, cubes of corneous silver-ore.

Hauy's Crystallography.

Having given a short view of the Wernerian Crystallo-phy, in the preceding pages, we shall now add an osition of the method followed by Hauy in determi-g and describing the various regular forms that occur he mineral kingdom.

We shall consider it in the following order.

1. Of the primitive forms.
2. Of the integrant molecules.
3. Of the laws of decrement.
   a. Decrements on the edges.
   b. Decrements on the angles.
   c. Mixed decrements.
   d. Intermediate decrements.
   e. Compound secondary forms.
   f. Of secondary forms, when the molecules differ from parallelopipeds.
4. Difference between structure and decrement.
5. Of those crystals in which the half is turned round, and of others that intersect each other.
6. Of the symbols used to denote the particular laws of decrement which produce the secondary forms.
7. *Lastly*, Of the nomenclature of crystals.

1. *Of the Primitive Forms.*

Crystals in which there are several cleavages, can, in general, be split in the direction of these cleavages. The fracture-surfaces or planes thus exposed, are either parallel with all the planes of the crystal, or they are not. When parallel with the planes, the crystal retains its form, however much we split it in the direction of its planes; it only changes in magnitude, becoming smaller and smaller as we continue the splitting. On the contrary, when the cleavages are not parallel with any of the planes of the crystal, or but with few of them, and when we continue the division until they meet together,

er, we obtain a regular figure, whose contour
different from that which the crystal first exhi-
and which may now be further subdivided in
rection of its planes. without undergoing any fur-
hange of form. This new regular form is by HAUY
l the *Primitive nucleus;* and the crystal whose form
same, the *Primitive form.*

as, if we split a cube of galena or lead-glance in the
ion of its cleavages, all the divisions will be pa-
with the faces of the cube, and by continued
ng in the same direction, the figure remains un-
ed, but the size gradually diminishes. On the
ry, if we begin to split a cube of fluor-spar in the
on of its cleavages, it first loses its eight angles,
e observe in their stead eight new shining triangu-
nes. By continuing the splitting, these new planes
e larger and larger, and the form of the crystal is
and more changed; at length, the six four-sided
of the cube disappear, and the eight triangular
meet, and form a regular octahedron. If the split-
still continued, the octahedron diminishes in magni-
ut does not change in form. The figure ABCDEFG
0. Pl. VII. represents a cube of fluor-spar. If we
t to split it by sections parallel to its planes or
we will obtain an irregular, not a foliated surface;
a section is made in the direction of the line *g f*, pa-
o the diagonal line A C, upon one of its faces B D,
an angle of about 54½°, it will split readily, and
id angle A *g h f* will be detached, and the new face
ill be an equilateral triangle. Fig. 81. Pl. VII.
the position of the cleavages on the eight angles of
e, which are marked with the letters *a b c d e f g h.*
continue to split the cube in the directions of these
cleavages,

cleavages, we will first obtain equilateral triangular faces; and when the sections intersect each other, the equilateral triangular faces will disappear and become hexagons. When the original faces of the cube entirely disappear, an octahedron, with triangular faces, will make its appearance, which is represented in Fig. 82. Pl. VII. as the nucleus contained in the cube. According to HAUY, the octahedron is the primitive form, and the cube a secondary form, of fluor-spar; whereas the cube of galena agrees with the primitive form, and also with the primitive nucleus of that mineral.

If we take a regular six-sided prism of calcareous-spar, Pl. III. Fig. 1. and attempt to divide it parallel to the edge of the base, we will find three of these edges taken alternately in the upper base; for example, the edges *l f*, *c d*, *b m*, will admit of this division, while the other three of them will not. To succeed in the lower base, we must not make choice of the edges *l' f'*, *c' d'*, *b' m'*, which correspond with the upper edges; but the alternate edges *d' f'*, *b' c'*, *l' m'*, Fig. 2 Pl. III. These six cuts will expose to view as many trapeziums. Three of these are represented in Fig. 2. Pl. III.; namely, the two which come in the place of the edges *l f*, *c d*, and which are marked by the dotted lines *p p o o*, *a a k k*, and that which comes in place of the lower edge *d' f'*, and which is marked by the dotted lines *n n i i*. Each of these trapeziums will have a polish and lustre, from which it will be easy to perceive that they coincide with the natural joints or cleavage of the prism. We will attempt in vain to divide the prism in any other direction; but if we continue the division parallel to the first cuts, it is obvious that the size of the bases will gradually diminish, while the prism itself will continue to grow shorter. Just when the bases disappear altogether, the prism

sm will be converted into a dodecahedron, Fig. 3. . III. with pentagonal faces; six of which, as *o o i* O *e*, [*k i i*, are the remains of the faces of the prism, and d the six others EAI*oo*, OA′K*ii*, are the result of the echanical division.

If we continue the splitting, the faces at the ends will eserve their figure and size, while the lateral faces will ntinually diminish in length, till at last the points *o*,*k* the pentagon *o* I *k i i*, being confounded with the points *i*, and the same thing happening with all the other oints similarly situated, each pentagon is converted into simple triangle, as we see in Fig 4. Pl. III. New lices taken off, make the triangles disappear, so that o vestige of the original prism remains. Thus we obain the prismatic nucleus, or what on a general view ay be called the Primitive Form, (Fig. 5. Pl. III.) hich consists of an obtuse rhomboid *, the inclination f whose planes is 105° 5′, and 75° 55′ and the plane ngles EAI and AIO 101° 32′ 13″, and 78° 8′.

In some minerals, however, as in those with a concealed foliated fracture, in quartz for example, we can sellom divide the crystal in the direction of the cleavage ntil it is heated red-hot, and thrown into cold water; y this process rents take place in the directions of the leavage, and enable us to split it regularly.

In other minerals, where this practice is inapplicable, we judge of the cleavage by the reflection of light sometimes observable in their interior, when they are turned in different directions before a strong light.

Lastly,

* By a *rhomboid*, Hauy means a figure rounded by six equal rhombuses, parallel two and two.

cleavages, we will first obtain [illegible] no cleavage is discoverable, and when the sections inter[illegible] and the figure of the pri-ral triangular faces wil[illegible] form, by conjecture from When the original faces [illegible] by the forms of the secondary an octahedron, w[illegible] pearance, which is [illegible] crystallisations of a mineral spe-nucleus contain [illegible] them, according to HAUY, have the octahedron is [illegible] and the planes of this form are al-condary form[illegible] with actually existing cleavages, or agrees wit[illegible] cleavages of which we consider it tive nuc[illegible] On the contrary, in different mineral If we [illegible] itive form may vary more or less. But Pl. [illegible] ent forms can be reduced to some one of [illegible] ing:

- [illegible] parallelopiped. Fig. 8. Pl. III.
- [illegible] octahedron. Fig. 9. Pl. III.
- The tetrahedron. Fig. 10. Pl. III.
- The regular six-sided prism. Fig. 11. Pl. III.
- The dodecahedron with rhomboidal faces, equal and similar. Fig. 12. Pl. III.
- The triangular dodecahedron with triangular faces, consisting of two six-sided pyramids, in which the lateral planes of the one are set on the lateral planes of the other. It is also named bi-pyramidal dodecahedron. Fig. 13. Pl. III.

I. *Parallelopiped.*

This is a solid figure, bounded by six faces, parallel t each other, two and two. Thus, for example, a cube is parallelopiped. It is evident, from this definition, th there may be a vast number of parallelopipeds, differi fro

r in the proportional length and breadth
d in the angles which these faces make
. About forty parallelopipeds have been
ed in the mineral kingdom. They may
into nine different kinds.

Cube, is a well known rectangular figure, bounded by six square faces, all equal to each other. Fig. 14. Pl. III. Examples, common salt, galena or lead-glance, common iron-pyrites, native gold, silver, and copper.

Right quadrangular prismwith square base, Fig. 15. Pl. III. It is a cube somewhat longer in one direction than in another; of course the only way in which it can vary, is in the relative lengths of two contiguous faces, the base, and one of the faces of the prism. For all the faces of the prism are, of necessity, equal and similar, being all rectangles. There are seven species which have this primitive form. In four of them the prism is shorter than the square base, while in three it is longer. Meionite, Wernerite, Epsom salt, and zeolite, have the prism shorter than the base; while in Vesuvian, red lead-ore, and titanite, it is longer.

Right quadrangular prism, but in which the *base*, instead of a square, is *a rectangle;* of course it admits of greater variation than the preceding, as both the length of the base, and of the prism, may vary. Fig. 16. Pl. III. Examples, euclase and prehnite.

4. *Right*

4. *Right quadrangular prism, in which the base is a rhomb*, Fig. 17. Pl. III. Examples, celestine and mica.

5. *Right quadrangular prism, in which the base is an oblique-angled parallelogram*, Fig. 18. Pl. III. Examples, epidote or pistacite, and axinite.

6. *Oblique-angled quadrangular prism, the base of which is a rhomb*, Fig. 19. Pl. III. Hornblende and augite are species which have this kind of primitive form.

7. *Oblique-angled quadrangular prism, the base of which is an oblique-angled parallelogram*, Fig. 20. Pl. III. Felspar is an example of a mineral with this kind of primitive form.

8. *Oblique-angled quadrangular prism, the base of which is a rectangle*, Fig. 21. Pl. III. Example, borate of soda or borax.

9. *Rhomboid with obtuse summits*, Fig. 22. Pl. III. In rhomboids of this kind there are two solid angles opposite each other, which differ from the other six. They are composed each of three obtuse plane angles, meeting together in a point; whereas the six others are formed of two acute and one obtuse angle. The line joining these obtuse solid angles is called the *axis* of the crystal, and the angles themselves constitute the *summits* of the crystal. The axis is the *shortest* line joining any two opposite angles in the respective rhomboids. Examples, calcareous-spar, chabasite and quartz.

10. *Rhomboid with acute summits*, Fig. 23. Pl. III. Two of the eight solid angles of this figure differ

fer from the other six. They are formed by the inclination of three acute plain angles to each other, whereas the other six are composed of two obtuse and one acute plain angle. The line joining these two acute and opposite solid angles, is called the *axis of the crystal*, and the angles themselves are called the *summits*. The axis is the *longest* line joining any two opposite angles of the crystal. Examples, corundum, iron-glance, and vitriol of iron.

II. *Octahedron.*

This may be defined a double four-sided pyramid, in ich the lateral planes of the one are set on the lateral nes of the other. There are four different kinds of s form, viz.

1. *Regular octahedron*, Fig. 24. Pl. IV. In this figure the triangular faces are equilateral and equiangular, and, of course, the base of the two pyramids is *a square*. Examples, diamond, spinel, fluor-spar, and magnetic ironstone.
2. *Octahedron*, in which the pyramids have *rectangular bases*, Fig. 25. Pl. IV. Each triangular face, of course, is isosceles, the two angles at the base being equal, and the angle at the summit different. It may be either acute, rectangular, or obtuse, according to the length of the rectangular base of the pyramids. The faces are equal and similar, four and four. Examples, white lead-ore, and sulphat of lead or lead-vitriol.
3. *Octahedron*, in which the pyramids have *a square base*, Fig. 26. Pl. IV. The pyramids, in gene-

ral, are very low, when compared with the si of the base, though this is not always the ca In anatase, for example, they are long, and course the solid angle at their summit is comp sed of very acute plane angles meeting at a poin Examples, zircon, tinstone, and cross-stone.

4. *Octahedron*, in which the pyramids have *a rhombo dal base*, Fig. 27. Pl. IV. They vary from eac other in the height of the pyramids, and th angles of the rhomb constituting the commo base of the pyramids. Examples, sulphur an sphene.

III. *Regular Tetrahedron*,

Is a figure bounded by four equilateral and equiangu lar triangles; or it may be described as a three-sided py ramid, terminated by a triangular base, Fig. 28. Pl. IV Examples, grey copper, and copper-pyrites or yellow copper-ore.

IV. *Regular Six-sided Prism*,

Is a prism composed of six equal rectangles, and ter minated at each extremity by a hexagonal plane or base Fig. 29. Pl. IV. They differ from each other in th height of the prism compared with the diameter of th base. Examples, emerald, apatite, and strontianite.

V. *Rhomboidal Dodecahedron*,

Is a solid bounded by twelve equal rhombs, Fig. 30 Pl. IV. Example, garnet.

VI. *Triangular Dodecahedron.*

It consists of two six-sided pyramids, joined base to base, and the common base, of course, is a regular hexagon. Example, witherite, Fig. 31. Pl. IV.

Of all these primitive forms, by far the most frequent are the parallelopiped and the octahedron. The six-sided prism is also pretty frequent, but the other three primitive forms, viz. the tetrahedron, the rhomboidal dodecahedron, and the triangular dodecahedron, occur but rarely.

2. *Of the Integrant Molecules.*

Sometimes the primitive nuclei, and primitive forms, besides their divisions or cleavages parallel with their planes, exhibit others in other directions, which are not parallel with their planes, or at least not with all of them, and thus give rise to a new figure, more simple than that obtained by the first mechanical division.

Thus, if we continue to cut slices from a six-sided prism, by cuts parallel to the lateral planes of the prism, we will divide the whole prism into a number of triangular prisms. This will be evident to the eye, by inspecting Fig. 32. Pl. IV., which represents the basis of a six-sided prism, divided into triangular prisms by such continued divisions. Sometimes a parallelopiped admits of divisions in other directions, besides those parallel to its faces. Suppose the rhomboid AA′KH, Fig. 33. Pl. IV. divisible both in the direction parallel to the six rhombs which constitute its faces, and likewise in planes passing through

through the oblique diagonal AO, the axis A′A, and the edge A′O, comprehended between the diagonal and the axis, the consequence of such a division would be, that the rhomboid would be separated into six tetrahedrons.

These tetrahedrons are represented in the figure surrounding the original rhomboid; and, to aid the conception, the same letters are employed to denote the same parts in the rhomboid, and in the tetrahedrons into which it is conceived to be divided. These forms are what Hauy names *integrant molecules*, and which he conceives to be the form of the ultimate integrant atom of the mineral in question. Hauy has also found, that the integrant molecules of all crystals, supposing them capable of being discovered by mechanical division, may be reduced to three species, viz. the Tetrahedron, Fig. 34, Pl. IV. the Triangular Prism, Fig. 35. Pl. IV, and the Parallelopiped, Fig. 36. Pl. IV. These three forms of the integrant molecules, like those of the primitive nuclei, and primitive forms, vary in their dimensions, and in the magnitude of their angles.

These integrant molecules arrange themselves in a variety of ways, and thus give rise to the different secondary forms. Hauy shews that these secondary forms may be accounted for, by supposing that layers of integrant molecules, arranged so as to form plates, are applied successively to all the faces of the primitive crystal, while each successive plate diminishes in size by the abstraction of a determinate number of integrant molecules (or parallelopipeds), either parallel to the edges, or the diagonal of the faces, or in some other intermediate direction. Sometimes decrements take place at once on all the edges, as when the rhomboidal dodecahedron is formed from the cube; or upon all the angles, as when the regular octahedron

is formed from the cube. Sometimes they take
nly on certain edges, or certain angles. Some-
hey are uniform, so that only one law exists of
ents, by one, two, three, &c. ranges, which acts up-
erent edged angles. Sometimes the law varies
e edge to another, or from one angle to another;
s happens chiefly when the nucleus has not what is
a *symmetrical form*, as when it is a parallelopiped,
faces differ in the respective inclinations of their
r in the measure of their angles. In certain cases,
rements on the edges concur with those in the
to produce the same crystalline form. It happens
, sometimes, that the same edge, or the same
undergoes different laws of decrement, which suc-
ch other. And, finally, there are a great many
where the secondary crystal preserves faces paral-
those of the primitive form, and which combine
e faces produced by the decrement to modify the
of the crystal. If, in the midst of such a diversity
, sometimes acting solitarily, and sometimes in
ation, upon the same primitive form, the number
ges subtracted were likewise very variable; if, for
e, there were decrements of 20, 30, 40, or a greater
of ranges of molecules, as is very possible in con-
; the multitude of forms which might exist in
ineral species, would be sufficient to confound the
ation; and the study of crystallography would
an immense labyrinth, from which, even when
l by the theory, it would be difficult to extricate
elf.

the force which produces the subtractions, appears
a very limited action. Generally these subtrac-
ake place only by one or two rows of molecules.

None

None have hitherto been observed beyond six rows such is the fecundity united with this simplicity supposing we confine ourselves to decrements b two, three, and four rows, and exclude those th mixed or intermediate, we find that the rhomb susceptible of 8,388,604 varieties of crystalli Doubtless many of these varieties do not exist in n But there is reason to expect, that discoveries in th of inquiry will be made in great numbers for a lon to come.

We have already remarked, that besides the par piped, there are two other shapes which the int molecules assume; namely, the tetrahedron, and t angular prism.

It is worthy of notice, that the tetrahedral an matic molecules are always arranged in such a man the interior of primitive and secondary crystals, th king them in groups of 2, 4, 6, or 8, they compo rallelopipeds; so that the ranges subtracted by the of decrement, are nothing else than these parallelo These parallelopipeds are by Hauy named *Subt Molecules.* They are always substituted in place trahedrons or triangular prisms, in considering t crements which produce the secondary forms in cases.

3. *Of the Laws of Decrement.*

In order to enable the reader to understand these various decrements, we shall give the follow lustrations from Hauy *.

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* I have here used the statement of Hauy, as given in the articl tallography, in the *Edinburgh Encyclopædia.*

a. *Decrements on the Edges.*

Let us suppose that the primitive form of a mineral species is the cube; but that secondary crystals of the same species likewise occur, having the form of the rhomboidal dodecahedron. How is this dodecahedron derived from the cube? Let us suppose, as may be done in every case, that the integrant molecule of this species is a cube; it follows that the primitive cubic crystal is formed by the congeries of a number of cubes. Suppose these cubes of such a size that an edge of the primitive crystal is composed of seventeen of these small cubes applied side by side. Of course every face of the primitive crystal will be composed of 289 squares, consisting of the bases of so many integrant molecules. According to this supposition, the primitive crystal will be a congeries of 4913 little cubes. Let us now suppose, that a square, consisting of the thickness of one integrant molecule, be applied to every face of the primitive crystal; but that, instead of being of the size of the face of that crystal, it be less than it by a single row of integrant molecules all round, so that its side, instead of 17 little cubes, contains only 15; and of course it contains only 225 little cubes, instead of the 289 that go to the formation of the face of the primitive crystal. Upon each of these first plates applied all round to every face, let another plate be applied similar to the first, but less than it by a row of integrant molecules, so that the side contains only 13 squares, and the whole plate only 169 squares. Let six other plates be applied in succession to each of the faces, diminishing by a row of little cubes all round, so that the sides of each consist of 11, 9, 7, 5, 3, I, squares, respectively. It is obvious, that, by this process,

cess, we have raised upon each of the six faces of the cube a four-sided pyramid, the faces of which, instead of being smooth, will, by their constant diminution in bulk, represent the steps of stairs. These pyramids having each four faces, constitute small 24 triangular faces; so that, by this process, we have converted the cube into a new crystal. It would seem, at first that this new crystal ought to have 24 triangular faces; but a little consideration will satisfy us, that the two adjacent triangular faces, in each pyramid, are in the same plane, and form together a rhomb; so that, in fact, the cube has been converted into a rhomboidal dodecahedron. Fig. 37. Pl. IV. represents the cubic nucleus, with the pyramids raised upon three of its faces; and Fig. 38. Pl. IV. represents the rhomboidal dodecahedron formed in this manner. This is an example of a secondary crystal formed by decrements on the edges of the plates. Suppose us in possession of such a crystal, it is easy to see how, by mechanical division, the cubic nucleus might be extracted. We would have only to cut off all the solid angles formed by four plain angles, by slices parallel to the shorter diagonals EO, OI of the rhombs.

In the preceding example, each plate was only of the thickness of one integrant molecule, and the decrement was only one row of integrant molecules all round; but we might have supposed the thickness of the plates to have equalled two or more integrant molecules, and the decrements might have been equal to two rows of integrant molecules, or more, at once. In that case, the form of the secondary crystal obtained would have been different from the rhomboidal dodecahedron.

It

It will be necessary here to explain the meaning of two terms, which we will have occasion to employ frequently hereafter. *Decrement in breadth* is used when the thickness or height of the plate is only equal to one integrant molecule; but one, two, three, &c. rows of molecules all round, we conceive to be abstracted from the breadth of each succeeding plate. *Decrement in height* is used when the plates only diminish by one row of integrant molecules in breadth, but their height may be equal to two, three, &c. molecules. In such cases, the decrement is expressed by saying, that it takes place by two, three, &c. rows in height.

It will be worth while to give another example of a secondary crystal formed by decrements on the edges of the faces. The primitive form of iron-pyrites is a cube; but, among a great variety of secondary crystals, there is one which occurs in the form of a dodecahedron with pentagonal faces. This crystal is represented in Fig. 89. Pl. IV. where the cubic nucleus may likewise be seen. From the inspection of that figure, it will be obvious, that, instead of a four-sided pyramid, as in the former case, a kind of wedge is formed upon each face of the cubic nucleus, which may be conceived to be the pyramid elongated in one direction. This wedge upon one of the faces of the cube, is represented by OO′ *t n* I I′. In this case, the decrements may be conceived to take place by two ranges in breadth between the edges OI and AE, II′ and OO′, EO and E′O′; and in the same manner upon the opposite faces; while, at the same time, they take place by two ranges in height between the edges EO and AI, OI and O′I′, OO′ and EE′. We see that these decrements take place upon the different faces of the cube in three directions, which cross each other at right angles. The decrement, by two

ranges in breadth, tending to produce a face more inclined than that which results from a decrement by two ranges in height; the consequence must be, that the structure of plates does not terminate in a point, as in the first example, but in a wedge. The lines *p q*, *t n*, Fig. 39. Pl. IV. represent the summits of two of these wedges. If we compare these summits *p q*, *t n*, with the summit *r s* of the wedge which covers the face EOO′E′ of the cubic nucleus, it will be easy to perceive that these three lines are perpendicular to each other respectively. Fig. 40, Pl. IV. represents the cubic nucleus with wedges raised upon two of its contiguous faces by means of plates pursuing decrements according to the law above described. The same letters are applied to the same parts of the crystal in Figs. 39. and 40. Pl. IV. At S′ is seen the extremity of the summit of a third wedge raised upon a third face of the cube. Each trapezium, such as O *p q* I Figs. 39. and 40. Pl. IV. being in the same plane with the triangle O *t* I belonging to the adjacent wedge, both together conspire to form the pentagon *p* O *t* I *q*, so that the secondary crystal formed by these decrements, instead of 24 faces, has only 12 pentagonal faces, and is therefore a dodecahedron as well as the first example, but a dodecahedron of a different kind.

We shall give a third example of these kind of decrements, because it contains something peculiar in it, but which often takes place in the formation of secondary crystals; and it is requisite that the reader should be aware of it. The dodecahedron represented in Fig. 6. Pl. III is a secondary crystal of calcareous-spar. In it the edges EO, OI, IK, &c. where the two opposite pyramids join, coincide with the edges of the primitive nucleus,

nucleus, as may be perceived by inspecting Fig. 7. Pl. III. The decrements set out from these edges, and do not take place at all upon the other six edges of the principal nucleus EA, AI, AG, OA′, &c. Now, it is easy to conceive, that the edges of the plates laid upon the primitive nucleus, form, by their sum, as many triangles E *s* O, I *s′* O, E *s′* O, &c. resting upon the edges from which they set out; and as these lines are six in number, there will be 12 triangles, six above, and as many below; and all these triangles will be scalene, in consequence of the obliquity of the edges from which the decrements set out.

With respect to the other edges of the plates of superposition, they will be so far from experiencing any decrement, that they will, on the contrary, augment, because they must always remain contiguous to the axis of the crystal, just as happens when the primitive crystal increases in size by the superposition of new plates, without undergoing any change of form. It is the province of mathematics, combined with observation, to determine the law of decrement upon which this dodecahedral form depends. If we suppose a decrement of one range, it may be demonstrated that the two faces produced on each side of the edge from which the decrement set out, will be in the same plane, and parallel to the axis of the primitive crystal, circumstances which do not suit the present case. If we suppose a decrement of two ranges in breadth, it may be demonstrated that the result will be a dodecahedron similar to the one which we are considering. Fig. 41. Pl. V. represents one of the pyramids of this dodecahedron formed by the superposition of plates following the law of decrements by two ranges

of

of particles. The line E *s* represents an edge of this pyramid such as it appears to the eye, E *s* such as it really exists; but the distance *s s'* is not sensible, in consequence of the extreme minuteness of the size of the intermolecules, by the abstraction of which the pyramids are formed. The same reason prevents the channels or steps of stairs upon the pyramids from being sensible. Though in some cases, when secondary crystals are formed with great rapidity, these channels may be perceived by the naked eye.

2. *Decrements on the Angles.*

Decrements on the edges, which have been just described, are not sufficient to account for all the diversity of forms which secondary crystals assume. To give an example; mineral species, the primitive form of whose crystals is the cube, are found crystallised in secondary forms, some of which are rhomboidal dodecahedrons. and others regular octahedrons. The formation of the rhomboidal dodecahedron has been explained above, by means of decrements on the edges. At first sight, it would appear that the octahedron might also be derived from the cube by decrements on the edges. We have only to take two opposite faces of the cube, and to suppose a four-sided pyramid raised upon each by means of decrements on the edges of the plates successively applied. While this is going on upon these two faces, we may suppose that the other four faces of the cube remain unaltered. Each of these two pyramids may be supposed to prolong itself downwards till they meet. The consequence would be

an

hedron enveloping the cubic nucleus; but it may
onstrated, that no law of decrement whatever
in this case form an octahedron with equilateral
lar faces, which is the case with the octahedron
from the cube. Besides, if we have recourse
hanical division, in order to obtain the cubic nu-
om this kind of octahedron, we shall find that the
gles of the cube coincide with the central points of
ht faces of the octahedron, which could not be the
the octahedron had been formed in the way we
en supposing. But if we suppose the decrements
place parallel to the diagonal of the faces of the
ll difficulty vanishes; we obtain the regular octa-
without difficulty. Such decrements are called
nts on the angles.

OI I′O′ Fig. 42. Pl. V. be one of the faces of the
ucleus, divided into a number of little squares,
are the bases of as many molecules. We may con-
ese molecules arranged in two different ways; they
parallel to the edges, as is the case with the mo-
a, n, q, r, s′, t′, v′, z′, s′; or they may be arran-
the direction of the diagonals, as is the case with
lecules *a, b, c, d, e, f, g, h, i,* and likewise with
lecules *n, t, l, m, p, o, r, s,* and likewise with the
les *q, v, k, u, x, y, z.* One of these rows of mole-
represented separately in Fig 43. Pl. V.
molecules parallel to the edges of the square touch
of their faces, and the ranges themselves are sim-
ced contiguous to each other. The molecules pa-
to the diagonals touch only by an angle, and the
are indented into each other. When secondary
s are formed by this last kind of decrement, the
ces are not merely channelled, as happens in the
case

case of decrements on the edges; they are all bristled with points, which being exceedingly minute, and all in the same plane, escape the eye, so that the faces appear smooth.

Having thus explained the meaning of the terms, let us illustrate this kind of decrement by an example; and we cannot get a better than the formation of a regular octahedron from a cubic nucleus. This is the consequence of the superposition of plates upon each face of the cube with decrements of a single range of molecules on the angles. Let AEOI, Fig. 44. Pl. V. A, be one of the faces of the cubic nucleus subdivided into 81 little squares, which are the bases of so many molecules, of which the face is conceived to be composed. Fig. 44. B, represents the first plate of superposition, which ought to be placed above AEOI, Fig. 44. A, in such a manner, that the point *e'* corresponds with the point *e*; the point *a'* with the point *a*; the point *o'* with the point *o*; and the point *i'* with the point *i*. It is obvious, from this manner of placing it, that the squares E *e*, A *a*, I *i*, O *o*, Fig. 44. A, remain uncovered; which is the initial effect of the decrement on the angles. We see likewise, that the edges QV, PN, LC, FG, Fig. 44. B, exceed by a range of molecules the edges EA, EO, OI, IA, Fig. 44. A. This is necessary to prevent re-entering angles, and is merely the consequence of the increase of size of the crystal, without any change of form in these quarters.

The upper face of the second plate of superposition, is represented by BKHD Fig. 44. C. It must be applied to the first plate in such a manner, that the points *e''*, *a''*, *i''*, *o''*, coincide with the points *e'*, *a'*, *i'*, *o'*, Fig. 44. B, which leaves bare another row of molecules parallel

to

o the diagonal. This plate also increases by a row of molecules at all its edges B, K, H, D, for the same reason as the first plate did.

The figure of these plates of superposition, which at first was an octagon, has now become a square. It is no longer necessary to continue the addition of rows of molecules at the edges; so that the succeeding plates retain the square shape, but constantly diminish in size, in consequence of the abstraction of a row of molecules from each edge parallel to the diagonal of the face of the cubic nucleus. These different plates are represented by Fig. 44. D, E, F, G, H, and I, in each of which the small accented letters denote the points of the plate that coincide with the same letters in the preceding plate. Eight plates are necessary, as appears from the Figure, and the last of them consists only of a single molecule.

If we suppose the same number of plates, of the same form, to be applied successively upon each face of the cubic nucleus, it is obvious that we raise upon each of the six faces of the cube a four-sided pyramid. Hence it would appear, at first sight, that the secondary crystal would have 24 faces. Each of these faces will have four edges, as must appear evident upon a little consideration, and will have the form represented in Fig. 45. Pl. V. in which the angle *o* is conceived to coincide with the angle O of the cubic nucleus, and the diagonal *t x* represents the edge HK Fig. 44. C of the plate BKHD. The triangle *t o x*, being composed of those plates of superposition the edges of which undergo an increment, will be much shorter than the triangle *t s x* formed of those plates of superposition whose edges undergo no increment; because the number of the first is much smaller than that of the second, they being to each other as 2 to 6.

Thus

Thus the surface of the secondary crystal is compos of 24 quadrilateral faces, arranged, three and thr round each angle of the cubic nucleus. But as in t decrements, by one range of molecules on the edges, t faces produced on both sides of the same edges are in t same plane, so in decrements by one range of molecul on the angles, the faces formed on the three sides of ea angle are in the same plane. This plane is represen ed in Fig. 46. Pl. V. where the three quadrilaterals su rounding the angle of the cube *o*, coincide to form t equilateral triangle *m n s*. Thus the faces of the secon ary crystal are reduced to eight equilateral triangles, a of course the figure is that of the regular octahedron.

If these decrements were to stop before they termin ted in a point, the consequence would be, that fac would remain parallel to the original faces of the cub and that the crystal would have fourteen faces, eig those of the octahedron, and six those of the cube; s that it would at once have the form of the cube and the octahedron. Nothing is more common than to fin such crystals both in iron-pyrites and in galena or lea glance.

If the decrements were more rapid, as, for example, i two or more ranges of molecules were abstracted, the the three trapezoids *s t o x*, *m t o r*, *n r o x*, (Fig. 46. formed round the same solid angle of the nucleus, woul not be in the same plane, but would be inclined upon ea other, and the secondary crystal would have 24 trapezo dal faces.

As another example of this kind of decrement, let u take the rhomboid, Fig. 47. Pl. V. which differs somewh from a cube by having acute angles. Let us suppose th the plates applied upon all the faces of this rhomboid suff

decremen

ecrements only at the angles contiguous to the summits A, O′, and that these decrements take place by two anges; then, instead of 24 faces, only six would be formd; and if we conceive these prolonged till they meet ach other, they would compose a very obtuse rhomboid, which would be the secondary crystal. Fig.48. Pl. V. reprerents such a rhomboid, with its primitive nucleus inclosed. We see that its summits, A, O′ coincide with the summits of the primitive rhomboid, from which the decrements commenced, and that each of its faces, as A*e o i*, corresponds with one of the faces AEOI of the nucleus, so that the diagonal which passes through the points *e*, *i*, is parallel to the diagonal EI of the face of the nucleus, and only somewhat more elevated. This kind of crystal is found among the secondary crystals of specular iron-ore or common iron-glance.

3. *Mixed Decrements.*

This name is applied to those decrements in which the number of ranges taken away in breadth and height give ratios, the two terms of which surpass unity. As, for example, decrements by two ranges of molecules in breadth, and three in height, or by three ranges in breadth and two in height, &c. It is easy to see that the theory may be with facility reduced to that of decrements, in which there is only one row of molecules taken away in one of the two directions.

4. *Intermediate Decrements.*

We have seen, that in the case of a decrement by one row of molecules round the same solid angle, the three faces produced are always in the same plane, and that, in

that case, it is only necessary to consider the effect of the decrement with respect to one of the plane angles which concur to the formation of the solid angle, conceiving this effect to be prolonged over the neighbouring faces. In that case, the decrements on these last faces are considered as *subsidiary*, to favour the action of the principal decrement.

In general, whenever the solid angle of a primitive crystal undergoes decrements which tend to produce a face in its place, whatever the law may be to which we reduce the production of that face, there are always auxiliary decrements, the concurrence of which is necessary, in order that the new face may be of the requisite magnitude. Now, when the decrement which we consider in preference takes place, by two ranges of molecules, or by a greater number, the auxiliary decrements in continuity with it follow a particular law, which it is necessary to explain.

Let AA′ Fig. 49. Pl. V. be a parallelopiped of any kind which undergoes a decrement by two ranges on the angle EOI of its base AEOI. It is obvious that the edges of the plates of superposition will have the directions *b c*, *r s*, parallel to the diagonal EI, and so situated that there will be upon the sides OE, OI two rows of molecules comprehended between the angle O and the line *b c*, and likewise between *b c* and *r s*. But, as has been already said, the plates applied upon the adjacent faces IOA′K, EOA′H undergo likewise auxiliary decrements, which continue the effect of the decrement upon the angle EOI. But such, in this case, are the effects of these decrements, that the edges of the plates applied upon IOA′K have the directions *c g*, *s t*; and those of the plates applied upon EOA′H the directions *b g*, *r t*. For

since

since the lower edge of the first plate applied upon AEOI coincides with *b c*, and the height of this plate corresponds to that of a single molecule, a little attention will satisfy us that the plane *b c g*, which on one part coincides likewise with *b c*, and on the other separates from the base AEOI, by a quantity measured by O*g* the height of a single molecule, is necessarily parallel to the face produced by the decrement. The same holds with the plane *r t s*. From this it follows, that if we suppress the part situated above *r t s*, we will have a solid on which the face *r t s* will represent the effect of decrement that we are considering.

Now the directions *cg*, *st* of the plates applied upon the face IOA'K (and the same may be said of the face EOA'H) in consequence of the auxiliary decrements, are neither parallel to the edge, nor to the diagonal of the face, but intermediate between the one and the other. This want of parallelism will become still greater, if we suppose the decrements upon the angle of the base EOI to take place by 3, 4. &c. ranges. This is the kind of decrement to which the name of *intermediate* has been given. It is obvious, that it may take place in an infinite number of different directions, according as it deviates more or less from its two limits, the parallelism with the edge, and the diagonal of the face.

In cases similar to those of Fig. 49. Pl. V. we avoid the complication introduced by these intermediate decrements, by supposing them comprehended under the principal decrement. But certain crystals exist, in which all the three decrements round the same solid angle are intermediate. In such a case, the simplest of the three is chosen as the principal decrement, and the other two considered

sidered as auxiliary. Fig. 50. Pl. V. represents a case of this kind; *c n*, which is the edge of the first of the plates applied upon AEOI, is so situated, that on the side of OI there are three molecules subtracted; while on the side OE there is only one: *n p*, which is the edge of the first plate applied upon IOA'K, indicates three molecules subtracted from OI, and two from OA'; *c p*, which is the edge of the first plate applied upon EOA'H, shews the subtraction of two molecules on OA', and only one on OE.

It is easy to see that the decrements take place relatively to the different faces situated round the angle O, as if the molecules that compose the different plates of superposition, being united invariably several together, compose other molecules of a higher order, and as if the subtraction took place by single ranges of these compound molecules. Thus there will be on the base AEOI a decrement of triple molecules by two ranges in height, since on one part the quadrilateral figure *c* O *n z*, which represents the base of a compound molecule, is equivalent to the bases of three simple molecules; and, on the other, the line O*p*, which corresponds to the height of a plate of superposition, is equivalent to the height of two simple molecules. It is easy to conceive, likewise, that the decrement relative to the face EOA'H takes place by two ranges in height of double molecules, because *c*O*px* contains the bases of two simple molecules, and O *n* is equal to the length of three simple molecules. In the decrement which takes place upon IOA'K there is a subtraction of one row of molecules triple in one direction, and double in the other.

Among these three decrements, the one which it appears most natural to adopt as the principal, is the second,

ond, which takes place upon the face EOA′H, because t is the one whose direction deviates the least from that of the diagonal EA′; or because it takes place by double molecules, which is a more simple decrement than the other two.

Suppose intermediate decrements on the two lateral angles G, G′ Fig. 51. Pl. V. of the face of a rhomboid, and that these decrements take place by ranges of double molecules, that is to say, parallel to the lines *u m*, *x y*, *u′m*, *x′y′*. It is evident that these decrements will produce above each rhomb of the primitive nucleus, such as SG*g*″G′, two faces, which commencing at the angles G, G′, will converge towards each other, and come in contact in a line situated above the diagonal S*g*″, but inclined to that diagonal; so that the complete result of the decrement will be the formation of twelve faces disposed six and six towards each summit. Fig. 52. Pl. V. represents one of these solids, with its nucleus inscribed. It is a variety of calcareous-spar which sometimes occurs. The lines *a b a′* shew the direction of a fracture parallel to the face G*g*′G′S of the primitive nucleus. It appears from this figure that the nucleus does not touch the secondary crystal, except by its lateral angles, which are situated in the edges BS′, D*s*′, C*s*′, &c. while in the dodecahedron of Bergman, represented in Fig. 6. and 7. and called by Hauy, *Metastic calcareous-spar*, the lateral edges of the nucleus coincide with those edges of the secondary crystal that constitute the common basis of the two pyramids, as is evident from inspecting Fig. 7. Pl. III.

Hitherto intermediate decrements have been observed only in a small number of instances, but they lead to forms as simple as the other, and give some curious results, which

which deserve to be studied in a mathematical point of view, without any reference to crystallography.

5. *Compound Secondary Forms.*

Simple secondary forms are those which proceed from a single law of decrement, the effect of which covers and conceals the nucleus, which only touches the surface of the secondary crystal by certain angles or edges. *Compound secondary forms* are those which are produced by several simultaneous laws of decrement, or by one law which has not reached its limit, so that faces remain parallel to the original faces of the nucleus, and which concur with the faces produced by decrement, to modify the form of the crystal. Suppose, for example, that the law which produces an octahedron from a cube (described above) should combine with that from which results the dodecahedron with pentagonal faces, Fig. 39. Pl. IV. The first of these laws would produce eight faces, which would have, for centres, the eight angles of the cubic nucleus. It is easy to see that each of these faces, that, for example, whose centre coincides with the solid angle O, Fig. 39. Pl. IV. will be parallel to the equilateral triangle whose sides pass through the points *p*, *s*, *t*. In like manner, the face whose centre coincides with the point O′, will be parallel to the equilateral triangle, whose sides pass through the points *s*, *n*, *p*′. But the second law produces faces situated as the pentagons, cut by the sides of the triangles *p s t*, *s n p*′. Now the section of these triangles upon the pentagon *t* O *s* O′ *n*, reduces the pentagon to an isosceles triangle, which has the line *t n* for the base, and the two other sides of which pass through the points *t*, *s*, and *n*, *s*. The same thing takes place with

ith the other pentagons. Hence it follows, that the se-
ondary crystal produced will be an icosahedron, bound-
d by eight equilateral triangles, and twelve isosceles tri-
ngles.

Fig. 53. Pl. V. represents this icosahedron, in which
he letters correspond with those of Fig. 39. Pl. IV. and
hew to the eye the relation between the two solids But
his icosahedron has dimensions much greater than those
f the icosahedron which would be obtained by making
ections of the eight solid angles of the dodecahedron,
ig. 39, Pl IV. which are identified with those of the
ucleus. This increase of size was necessary to preserve
he size of the nucleus. This will be better understood
y the following illustration.

If we wished to obtain the nucleus from the icosahe-
ron of Fig. 53. Pl. V. it is evident that the fractures
ust be made in directions parallel to the edges *r s*, *t n*,
q, Fig. 39. and 53, so that they should be equally
clined upon the faces of which they form the junction.
hese planes would pass at the same time through the
quilateral triangles *p s t*, *s n p'*, &c. and we would obtain
he nucleus when they all met at the centres of the equi-
ateral triangles.

It follows from this, that the nucleus, the edges of
hich OI, OE, &c. Fig. 39. Pl. IV. were uncovered up-
n the surface of the dodecahedron, is entirely enveloped
the icosahedron, Fig. 53. Pl. V. excepting its solid
gles, which are only points, and which constitute the
ntres of the equilateral triangles. This being under-
ood, in order to form an accurate idea of the structure
the icosahedron, we must conceive that the plates ap-
ed to the nucleus for a certain period undergo decre-
nts only at the angles, as if the secondary solid were
to

to be a regular octahedron. Beyond this term (the decrement on the angles continuing always) a new decrement takes place and combines with the preceding; and this new decrement being relative to the dodecahedron, produces the twelve isosceles triangles. In this manner we see how the nucleus is entirely inclosed in the dodecahedron, excepting the solid angles. The first plates of superposition, which only underwent a decrement on the angles, continued to envelope the nucleus by those portions of their edges which underwent no decrements. It is sometimes necessary to suppose, in this manner, different epochas to different decrements, which concur to produce a compound secondary form, when we wish to give a particular account of the mechanism of the structure.

From this statement it follows, that the distance between the centres of the equilateral triangles *p t s*, *q t s*, Fig. 53. Pl. V. ought to be equal to the corresponding edge OI of the nucleus, Fig. 39. Pl. IV. as it evidently is to the eye, as any one may satisfy himself by inspecting the two figures.

The icosahedron just described, occurs among the secondary crystals of iron-pyrites. Naturalists at first were disposed to consider this as the regular geometrical icosahedron. But it has been demonstrated by HAUY, that the regular icosahedron does not exist among crystals, and cannot be produced by any law of decrement whatever. The same remark applies to the dodecahedron of mathematicians, a solid bounded by twelve regular and equal pentagons. No such crystal exists, nor can be produced by any law of decrement whatever. Of the five regular solids of mathematicians, the cube, the tetrahedron, the octahedron, the dodecahedron, and the icosahedron,

hedron, the first three occur in the mineral kingdom, ut not the last two.

It will be worth while to give another example of a ompound secondary form; and we shall take for that urpose the regular six-sided prism of calcareous-spar, 'ig. 1. Pl. III. From the account formerly given of the anner of dissecting this prism, it is easy to conceive that s rhomboidal nucleus AA′, Fig. 5. has its solid lateral ngles E, O, I, K, G, H, situated in the middle of the aces of the prisms; from which it follows, that these ngles are the points from which the decrements set out hat produce these faces.

These decrements act at once upon the three plane ngles EOI, EOA′, IOA′; but we may satisfy ourselves vith considering the decrement relative to one of these ngles, supposing the face which results from it extends tself upon the two adjacent rhombs belonging to the ame angle. Let us agree, therefore, to restrict the vhole to the six angles EOI, EHG, IKG, HGK, OIK, IGO, the three first of which are turned towards the ummit A, and the three last to the summit A′. If ve suppose a decrement by two ranges of rhomboidal nolecules on these different angles, six faces will be roduced parallel to the axis, as has been already ob- erved.

The plates of superposition, at the same time that they ndergo a decrement towards their inferior angles, will xtend by their superior parts so as to remain always ontiguous to the axis, the length of which will progres- ively augment. The faces produced by the decrement vill gradually increase, and when they touch each other ve shall have the solid AA′, Fig. 4. where each of the aces, as o O o, is marked by the same letter as the angle

O, Fig. 5. to which it belongs, and which is now situated in the middle of the triangle *o* O *o*, because it constitutes the common point from which the three decrements set out.

In proportion as new plates are applied after this to the preceding ones, the points *o*, *o* rise up, while the point O sinks down, so that at a certain period we shall have the solid represented by Fig. 3. where the faces produced by the decrements are become pentagons, such as *o o i* O *e*.

Things being in this state, let us suppose a second decrement to concur with the first, and to take place by a single range upon the superior angle EAI, Fig. 5. and its opposite angle HA′K, always with this condition, that the face produced by it on both ends of the figure is continued upon the two rhombs adjacent to that to which the angles EAI, HA′K belong. The effect of this decrement will be, to produce two faces perpendicular to the axis; and when it has reached the point at which these faces cut the six faces parallel to the axis produced by the first decrement, the secondary solid will be completed, and will be a regular six-sided prism Fig. 1. Pl. III.

We have already said that this result is general, whatever be the measure of the angles of the primitive rhomboid. We now see why, in the mechanical division of the prism, the cut *p p o o*, Fig. 2. Pl. III. has its sides *p p*, *o o* parallel to each other, and to the horizontal diagonal EI, Fig. 5. Pl. III.; since the two decrements taking place, the one upon the angle EOI, the other upon the angle EAI, the plates of superposition ought to have their edges turned towards this same diagonal.

In the case which we have been considering, and which is the most usual, the axis of the secondary crystal is longer

onger than that of the nucleus; so that this nucleus having its lateral angles contiguous to the faces of the prism, its summits are inclosed within the prism, at a certain distance above the centre of the bases. If we were to suppose that the two decrements began at the same time, in that case the axis of the prism would be equal to that of the nucleus, and the lateral angles and summits of the nucleus would be tangents, the one to the faces of the prism, the other to its bases. If the decrements on the superior angles of the nucleus were anterior to the other decrements, which is the opposite of the first case, the summits of the nucleus would then be contiguous to the bases of the prism, while its lateral angles would be wholly within the prism, between the axis and the prismatic faces. This is the case with certain crystals in which the prism is very short, and resembles an hexagonal plate.

Of Secondary Forms, when the Molecules differ from Parallelopipeds.

It is a character common to all the primitive forms, to be divisible parallel to their different faces. In the parallelopiped, when it is not joined by some other in a different direction, such a division leads us obviously to the form of a molecule, similar to that of the primitive crystal. In the regular six-sided prism, it gives us for a molecule a triangular equilateral prism. In the octaedron, it appears to produce molecules of two different forms, some by tetrahedrons and octahedrons: the same thing happens with respect to the tetrahedron. Various ideas have been suggested by philosophers to get over the difficulty in this case. Dr Wollaston has got rid of it supposing the molecules to be spherical, and to produce

duce the tetrahedrons and octahedrons, by combining in fours and sixes. HAUY conceives that the tetrahedron is the integrant molecule, and that the octahedrons are nothing else than empty spaces between the molecules, produced by these molecules uniting by their angles. The subject does not admit of decision; but as it is of no consequence to the theory of crystallography what opinion we adopt, there is no occasion to enter upon the discussion of the subject here. The rhomboidal dodecahedron, when divided in this manner, gives tetrahedrons of isosceles triangular faces, equal and similar to each other.

With respect to the dodecahedron with isosceles triangular faces, we cannot extract its integrant molecules without dividing it in directions different from those which are parallel to the faces. The cutting planes must pass through the axis, and through the edges contiguous to angles of the summit. The molecules obtained are irregular tetrahedrons. The other primitive forms sometimes admit of division in directions parallel to the faces. This is the case with the rhomboid, which constitutes the primitive form of the tourmaline. It may be divided by planes passing through the axis and the oblique diagonals. The result is the production of tetrahedral molecules, such as are represented in Fig. 33. Pl. IV.

Thus, besides parallelopideds, there are two other shapes which the integrant molecules assume; namely, the tetrahedron, and the triangular prism. Now, it deserves attention, and it is a point of considerable consequence in the theory of crystals, that the tetrahedral and prismatic molecules are always arranged in such a manner in the interior of primitive and secondary crystals, that,

iat, taking them in groups of 2, 4, 6, or 8, they compose parallelopipeds; so that the ranges subtracted by he effect of decrement, are nothing else than these paralelopipeds.

In order to conceive the better how this may be, let s suppose for an instant that the molecules of calcaeous-spar are divisible into tetrahedrons, as is the case vith the rhomboid, which constitutes the primitive form f the tourmaline. This supposition will change nohing in the explanation of the different forms of which calcarsous-spar is susceptible; that is to say, that in letermining the forms of this mineral, aided by the heory, we may always satisfy ourselves with considering decrements by one or more ranges of rhomboidal molecules.

What is only a hypothesis with respect to calcareous spar, is a reality with regard to the tourmaline. But although the rhomboids, to which we arrive by mechanical division in this species, are themselves divisible into tetrahedrons, still the decrements which produce the secondary forms take place by the subtraction of rhomboids similar to the primitive form; so that we may suppose, in the calculations relative to the determination of these forms, that the tetrahedrons which constitute the true molecules are united together in an invariable manner, in each rhomboid.

Let us take another example from those crystals whose primitive form is a regular six-sided prism. Let AD, Fig. 32. Pl. IV. be the base of such a prism, divided into small triangles, which constitute the bases of the integrant molecules. It is evident, that any two neighbouring triangles whatever, such as A *p i*, AO *i*, compose a rhomb, and of course the two prisms to which they belong form

by

by their union a prism with a rhomboidal base, which is a species of parallelopiped. If we conceive that the two triangular prisms, which constitute elements of the parallelopipeds, are invariably united together, it is obvious that we may consider the six-sided prism as composed of rhomboids instead of triangular prisms. Now, if we conceive a series of plates piled upon the hexagon ABCDFG Fig. 32. which undergo, for example, upon their different edges, a subtraction of one row of parallelopipeds similar to those that we are supposing here, these edges will successively correspond with the lines of the hexagon *i l m n r h, k u x y g e*, &c.; from which we see, that the quantity by which each plate passes the other is a sum of parallelopipeds or prisms with rhomboidal bases; and it is easy to judge, that the result of the decrement, supposing it to reach its limit, will be a right hexangular pyramid, which will have for its base the hexagon ABCDFG.

All the other primitive forms different from the parallelopiped, give analogous results. We might even substitute for each of these forms a nucleus similar to the little parallelopipeds, which are formed by the union of the tetrahedrons or triangular prisms, and we would succeed equally in explaining the secondary forms by laws of decrement applied to that nucleus, which would be obtained likewise by mechanical division.

Hauy calls these parallelopipeds composed of tetrahedrons or triangular prisms, *subtractive molecules*. They are always substituted in place of the tetrahedrons or triangular prisms, in considering the decrements which produce the secondary forms in these cases. Thus, as far as the theory of crystals is concerned, we have nothing

nothing to do with the integrant molecules, but may conceive all crystals composed of a congeries of parallelopipeds.

4. *Difference between Structure and Increment.*

In the preceding exposition of the Theory of Crystallography, it has been supposed that the laminæ of which the crystals of the same species are composed, proceed from a commom nucleus, undergoing decrements subjected to certain laws, upon which the forms of these crystals depend. But this is only a conception adopted in order to make us more easily perceive the mutual relations of the form in question. Properly speaking, a crystal is only a regular group of similar molecules. It does not commence by a nucleus of a size proportioned to the volume which it ought to acquire, or, what comes to the same thing, by a nucleus equal to that which we extract by the aid of mechanical division; and the laminæ which cover this nucleus, are not applied successively upon each other in the same order in which the theory regards them.

The proof of this is, that among crystals of different sizes, which are frequently attached to the same basis, the most minute are as perfectly formed as the largest; from which it follows, that they have the same structure, that is to say, they already contain a small nucleus, proportioned to their diameter, and enveloped by a number of decreasing laminæ, necessary in order that the polyhedron should be provided with all its faces. We do not perceive these various transitions from the primitive to the secondary forms, which, however, ought to be discoverable, if, during the process of crystallisation, the pyramids

ramids resting on the nucleus were formed progressively in layers from the base to the apex. This, however, is only true in general; for it sometimes happens, in artificial crystallisation, (and it is probable that it also occurs in natural bodies,) that a form, which had attained to a certain size, suddenly experiences variations by the effect of some particular circumstance. We must therefore conceive, for example, that from the first moment a crystal, similar to the rhomboidal dodecahedron, is already a very small dodecahedron, which contains a cubical nucleus, proportionally small, and that this kind of embryo continues to increase, without changing its form, by the addition of new laminæ on all sides; so that the nucleus increases on its part, always preserving the same relation with the entire crystal.

We shall make this idea more distinct by a construction, which refers to the dodecahedron already mentioned, and represented by means of a plane figure. What we shall say of this figure, may be easily applied to a solid, since we may always conceive a plane figure, like a section made in a solid.

Let *t s z s'*, Fig. 54. A, Pl. V. be an assortment of small squares, in which the square BNDG, composed of 49 imperfect squares, represents the section of the nucleus, and the extreme squares *t*, *p*, *i*, B, *f*, *c*, *s*, &c. that of the kind of steps formed by the laminæ of superposition. We may conceive, that the assortment has commenced by the square BNDG, and that different piles of small squares are afterwards applied on each of the sides of the central square; for example, on the side BN, at first the five squares comprehended between *f* and *h*, afterwards the three squares, contained

between

between *c* and *e*, and then the square *e*. This progress corresponds with what would take place if the dodecahedron commenced with a cube proportioned to its volume, and which afterwards increased by an addition of laminæ continually decreasing

But, on the other hand, we may imagine that the assortment had been at first similar to that which is represented by Fig. 54. C. Pl. V., in which the square BNDG is only composed of nine molecules, and had on each of its sides only a single square *s*, *t*, *s'*, *z*. If we refer, in imagination, this assortment to the solid of which A is the section, we shall easily judge that this solid had for its nucleus a cube composed of 27 molecules, and of which each face, composed of nine squares, carried on that of the middle a small cube, so that the decrement of one range is already exhibited in this initial dodecahedron. By application of new squares, this assortment will become that of Fig. 54. B. Pl. V. in which the central square BNDG is formed of 25 small squares, and supports on each of its sides a pile of three squares, besides a terminal square *s*, *t*, *s'*, or *z*. Here we have already two laminæ of superposition instead of one only. Finally, by an ulterior application, the assortment of Fig. 54. B. Pl. V. will be changed into that of Fig. 54. A. Pl. V. where we see three laminæ of superposition.

These different transitions, of which we are at liberty to continue the series as far as we please, will give an idea of the manner in which secondary crystals may increase in magnitude, and still preserve their form; from which we may judge that the structure keeps pace with this augmentation of volume; so that the law, according to which all the laminæ are applied on the nucleus, when it

 has

has attained its greatest diameter, and which successively decrease, was already sketched in the nascent crystal.

5. *Of those Crystals in which one half is turned round, and of others that intersect each other.*

Having considered the most perfect and regular form of crystals, we shall now speak of certain accidents, which, under the appearance of exceptions or anomalies, still possess a latent tendency toward the same laws to which the structure is subjected, when nothing deranges their progress, or disturbs their harmony.

In ordinary crystals, the faces adjacent to each other always form salient, and never re-entering angles. But crystalline forms also exist which present these last angles; and Rome' de Lisle was the first who observed, that this effect took place when one of the two halves of a crystal was in a reversed position with respect to the other. A very simple example will enable us to conceive this reversed position.

Let us suppose that B *d*, Fig. 55. Pl. VI. represents an oblique prism, with rhombic bases, situated in such a manner, that the faces AD *d a*, CD *d c*, are vertical, and BD are the acute angles of the base; and the latter proceeds in an ascending direction from A towards C. Let us also suppose, that the prism is cut into two halves, by means of a plane which should pass by the diagonals drawn from B to D, and from *b* to *d*, and that the half situated on the left, remaining fixed, the other is reversed, without being separated from the former. The crystal will be presented under the aspect which we see in Fig. 56. Pl. VI., where the triangle *b' d' c'*, which was

one

one of the halves of the inferior base, Fig. 55. Pl. VI. is now situated on the upper part, Fig. 56. Pl. VI. and forms a salient angle with the fixed triangle ABD; while the triangle BDC, Fig. 56. Pl. VI. which was one of the halves of the superior base, Fig. 55. Pl. VI. is transported into the lower part, Fig. 56. Pl. VI. and forms a re-entering angle with the fixed triangle *a b d*.

We can easily conceive that the plane of junction DB *b d* of the two halves of a rhomboid, is situated like a plane produced by a decrement of one range on one or other of the edges A *a*, C *c*, Fig. 55. Pl. VI.; and thus the manner in which these halves join, is in strict relation with the structure.

Now if we imagine a secondary form, which has for its nucleus the same prism, and if we suppose that it has been cut in the direction of the plane DB *b d*, and that one of its halves is reversed in such a manner, that the half of the nucleus which corresponds with it, assumes the same position as in the preceding case, the arrangement might be such, that there is still a re-entering angle on the one hand, and a salient angle on the other, which will result from the mutual incidences of the faces produced by the decrements.

In certain cases, the plane of junction, on which the two halves of the crystal are joined, is situated parallel to one of the faces of the nucleus, and the arrangement does not admit of presenting a re-entering angle opposite to a salient angle.

Hauy has given to these reversed crystals the name *hemi-tropes*, denoting one-half reversed.

Another accident, extremely common, is the manner in which grouped crystals are inserted into each other. This kind of apparent penetration is subject to so many diversities;

diversities, that frequently, among crystals of the same group, we do not find two relative positions resembling each other. But although, in general, the positions in grouped crystals are extremely variable, we find, on more accurate examination, that they are subject to certain laws always analogous to those of structure.

Let us take a simple example to illustrate this. Let AC, Fig. 57. Pl. VI. be a cube, and MN r an equilateral triangular facet, produced in place of the angle A, in consequence of a decrement by one range round this same angle. Let us suppose a second cube modified in the same manner, and attached to the former by the facet which results from the decrement indicated by M, N, r. We shall have the assortment represented by Fig. 58. Pl. VI.

We may now conceive that one of the two cubes, that, for example, which is placed below, is increased in all its dimensions, except at the places where the other forms an obstacle to it. In proportion as this increment becomes more considerable, the upper cube will be more and more enveloped in the inferior one, and it may even finish by being entirely concealed by it. We observe crystals sunk into each other all degrees of depth, but always in such a manner, that their plane of junction has a position analogous to planes resulting from decrement, so that both structures follow their ordinary progress, to this plane, which serves as their mutual limit or boundary. Hauy having divided cubes of fluor-spar inserted into each other, remarked, that the folia of each, extended without interruption, until stopped by the common plane of junction.

The example just mentioned relates to a very simple and very regular law of decrement. But frequently the laws

ws which determine the plane of junction are more or ss complicated, and there are a few which are somewhat xtraordinary.

When two prisms cross towards the middle of their xis, there are two planes of junction which unite, cross-g each other, as in the mineral named *grenatite*, Fig. 63. l. III. of *System of Mineralogy*, and these planes have ositions analogous to those which would be determined nmediately by the known laws of decrement.

. *Of the Symbols used to denote the particular Laws of Decrement which produce the Secondary Forms.*

Hauy has invented particular symbols, to denote the articular laws of decrement which produce the se-ondary forms. As these symbols occur constantly not nly in his writings, but also in those of all the authors f the same school of mineralogy, and as they are useful y greatly shortening the account of the formation of se-ondary crystals, we shall here explain them.

Let Fig. 59. Pl. VI. represent an oblique parallelopiped, he faces of which have angles with different measures, nd let it be the primitive form of some mineral; as, for xample, of felspar.

The vowels are adopted to represent the solid angles. The four first, A, E, I, O, are placed at the four angles f the superior base following the order of the alphabet, nd that of ordinary writing, namely, beginning at the op, and going from left to right.

The consonants are chosen to denote the edges. The ix first, B, C, D, F, G, H, are placed on the middle of he edges of the superior base, and upon the two longitu-inal edges of the lateral faces, which occur first in going from

move round the crystal till he is opposite to that angle, as he is naturally opposite to the angle O in the case which we have been describing; or, what comes to the same thing, he is conceived to turn round the crystal till the solid angle that he is considering be exactly opposite to him, and it is relative to that position that a decrement is said to take place towards the right or towards the left.

For example, if we are speaking of the solid angle A, the sign A^2 will represent the effect of a decrement by two ranges on the surface AE *s r*, Fig. 60. Pl. VI. or upon that which is opposite to T, Fig. 59. Pl. VI.; and ${}^3A$ will represent the effect of a decrement by three ranges upon the face AI *u r*, Fig. 60. Pl. VI. or upon that which is opposite to M, Fig. 59. Pl. VI.

As to the decrements on the edges, those which take place towards the boundary BCFD of the base, are expressed by a number placed above or below the letter, according as their effect takes place in going up or going down, supposing them to set out from the edge to which they are referred; while those which take place on the longitudinal edges G, H, are indicated by an exponent placed on the right or the left of the letter, according as they take place in one direction or the other. Thus $\overset{4}{D}$ expresses a decrement by two ranges proceeding from D towards C; $\overset{3}{C}$ a decrement by three ranges going from C towards D; $\underset{2}{D}$ a decrement by two ranges, descending upon the face M; ${}^3H$ a decrement by three ranges, proceeding from H towards G; ${}^4G$ a decrement by four ranges, proceeding from G towards the edge opposite to H, &c.

When

When it is necessary to denote by a small letter, such as *d*, a decrement upon the edge *u r*, Fig. 60. Pl. VI. opposite to the edge denoted by the capital letter D, Fig. 59. Pl. VI., we must suppose the crystal turned upside down. Hence $\overset{2}{d}$ will express a decrement by two ranges upon the base *p*, just as $\overset{2}{D}$ expresses a similar decrement on the base P. For the same reason, $\overset{3}{c}$ will express a decrement by three ranges, proceeding from *s p* towards EO, Fig. 60. Pl. VI.

If the same solid angle, or the same edge, undergo several successive decrements on the same side, or different decrements which take place on different sides, in that case, the letter pointing out the angle or edge is repeated as often as the decrements, varying the figure each time, to make it correspond with the particular decrements pointed out. Thus, $\overset{2}{D}\,\overset{3}{D}$ will denote two decrements upon the edge D, one of two ranges upon the base P, another of three ranges upon the face M. $^{2}H\ ^{4}H$ will denote two decrements, the one by two ranges, the other by four, on the left of the edge H.

Mixed decrements are marked according to the same principles, employing the fractions $\frac{2}{3}$, $\frac{3}{4}$, &c. which represent them; the numerator referring to the decrements in breadth, and the denominator to decrements in height.

The method of describing the intermediate decrements still remains to be explained. This will be best done by an example. Let AEOI, Fig. 61. Pl. VI. be the same face as in Fig. 59. Pl. VI. Let us suppose a decrement by one range of double molecules, according to lines parallel to *x y*, so that O*y* measures the double length of a

molecule, O x lines equal to a single molecule. This kind of decrement is written in this manner, $(\overset{1}{O}\ D^1 F^2)$. The parenthesis lets us know, in the first place, that the decrement is intermediate; $\overset{1}{O}$ indicates that it takes place by one range upon the angle marked by that letter; and that it belongs to the base AEOI, Fig. 59. Pl. VI. $D^1 F^2$ indicates that there is one length of a molecule taken away along the edge D, and two lengths along the edge F.

It is useful to have a language to denote these symbols, so that they may be easily written down when dictated by another person. On that account, we shall mention here the mode followed for that purpose. The symbols O^2, ^3O, are thus read: O *two on the right*, O *three on the left*, $\overset{3}{O}$, $\underset{4}{O}$ thus, O *under two*, O *above four*. Finally, the symbol $(\overset{1}{O}\ D^1 F^2)$ thus, *in a parenthesis*, O *under one*, D *one*, F *two*.

We must now notice the order in which these letters must be placed, in order to denote a secondary crystal. If the alphabetical order were adopted, there would result a sort of confusion in the picture which the formula presents. It is more natural to conform to the order which would direct an observer in the description of the crystal; that is to say, to begin with the prism or the middle part, and to indicate its different faces as they present themselves successively to the eye; then to pass to the faces of the summit or the pyramid.

Suppose, now, that Fig. 62. Pl. VI. represents the dodecahedral variety of felspar, the primitive form of which is seen in Fig. 59. Pl. VI. In this variety,

ty, the face *l*, Fig. 62. Pl. VI. results from a decrement by two ranges on the edge G, Fig. 59. Pl. VI. going towards H. The face M, Fig. 62. Pl. VI. corresponds with that which is marked with the same letter in Fig. 59. Pl. VI. and which is only concealed in part by the effect of the decrement. The face T, Fig. 62. Pl. VI. is parallel to T, Fig. 59. Pl. VI. The pentagon *x*, Fig. 62. Pl. VI. comes from a decrement by two ranges on the angle I, Fig. 59. Pl. VI. parallel to the diagonal O. As this decrement does not reach its limit, the summit exhibits a second pentagon P, Fig. 62. Pl. VI. parallel to the base P, Fig. 59. Pl. VI. All this description may be exhibited in symbolic language, as follows:

^{2}M T $\overset{2}{\text{I}}$ P.

In order to prevent beginners from finding any thing ambiguous in this symbolical mode of writing, especially in complicated cases, Hauy is in the habit of placing under the different letters which compose the symbol, those which correspond to them in the figure. If we adopt this mode, which is a considerable improvement, the symbol denoting *bibinary* felspar will be as follows: G^{2}M T $\overset{2}{\text{I}}$ P.

l M T *x* P.

These letters thus written below, enable us to compare the symbol with the figure, and thus to decypher the meaning with facility, how complicated soever it should be. But some more observations will be necessary, in order to understand fully the way in which these symbols are employed.

Let us now, then, turn our attention to parallelopipeds of a more regular form than that which constitutes the primitive

primitive crystal of felspar. But let us suppose them at first not to be rhomboids. They are nothing else than what is represented in Fig. 59. Pl. VI. but the form has varied, so as to render them symmetrical. In consequence of this alteration, certain angles and edges, which differed from each other in the first parallelopiped, have become equal in this. Hence, every thing that takes place on one of them is repeated on the other. They ought, therefore, to be denoted by the same letter. Thus, in algebra, certain general solutions are simplified in particular cases, when a quantity, at first supposed to be different from another, becomes equal to it.

Let us suppose, for example, that the primitive form is a rectangular prism, having oblique angled parallelograms for its bases, one side of which is longer than the other. In that case, we have O=A, Fig. 59. Pl. VI. I=E, &c. In such a case, the first letter of the alphabet will be substituted for the other, as is done in Fig. 63. Pl. VI.

If we pass through the different kinds of parallelopipeds, we shall find them acquire different degrees of simplicity, which occasions new equalities in the angles and edges, and of course new substitutions of letters. We shall have successively,

The oblique prism with rhomboidal bases, respresented in Fig. 19. Pl. III.

The rectangular prism, with rectangular bases, represented in Fig. 16. Pl. III.

The rectangular prism, with rhomboidal bases, represented in Fig. 17. Pl. III.

The rectangular prism, with square bases, represented in Fig. 15. Pl. III.

The

The cube represented in Fig. 63. Pl. VI. Here only the uperior base is marked with letters, because what takes place with respect to it may be applied indifferently to any of the other faces.

The same mode is followed in writing the symbols for these different forms, only the letters that have the same name and the same figures, are not repeated. An example will render the method evident. Fig. 64. Pl. VI. represents the most common variety of the *crysoberyl*, the nucleus of which is a rectangular parallelopiped, such as is represented in Fig. 65. Pl. VI. The symbol of the secondary crystal will be $\begin{matrix} M\ T\ {}^{2}G\ G^{2}\ \overset{1}{B}\ A^{\frac{5}{2}\,\frac{5}{2}}A. \\ M\ T\ \ s\ \ i\ \ o \end{matrix}$

This variety is called Annular *Crysoberyl*

To understand the preceding expression better, let us mark each angle and edge with a particular letter, as if the parallelopiped were oblique angled. See Fig. 65 a Pl. VI. In that case, the symbol would become $MT\ {}^{2}G\ H^{2}\ \overset{1}{B}\ \overset{1}{F}\ E^{\frac{5}{2}\,\frac{5}{2}}O$. But if we compare Fig. 65 a. with Fig. 65. we see, that H=G, F=B, O=A, &c. Hence, if we substitute, instead of the first letters, their values, we get $MT\ {}^{2}G\ G^{2}\ \overset{1}{B}\ \overset{1}{B}\ A^{\frac{5}{2}\,\frac{5}{2}}A$, which becomes the same with the one given above, when the useless repetition of $\overset{1}{B}$ is suppressed.

From the preceding statement, it is evident that we must take care not to confound, for example, ${}^{2}G\ G^{2}$ with $G^{2}\ {}^{2}G$. The first symbol indicates the decrements which take place on the face T, Fig. 65. Pl VI. and on the face opposite to it, going from the edges G towards those that correspond with them behind the parallelopiped. The second indicates the decrements which take place upon the face M,

M, and which meet each other in the middle of that face. If these two decrements took place simultaneously, their symbol would be $^{2}G^{2}$.

In the preceding symbols, each letter, such as ^{2}G or G^{2} can only be applied to a single edge, situated to the right or the left, as that letter itself. But $^{2}G^{2}$ applies indifferently to the one edge or the other. Hence, it is needless to repeat that letter.

Let us take the Figure 66. as another example*. If we suppose Fig. 17. to represent its primitive form, we will have for the symbol of the variety of crystal here represented, $^{5}G^{5}\ M\ \overset{2}{B}\ \overset{5}{B}\ \overset{1}{E}\ \overset{2}{E}\ P.$

$o\ M\ r\ s\ z\ u\ P.$

In this symbol $^{5}G^{5}$ indicates two distinct faces formed on each side of each edge G. But it is not necessary to place two letters under that symbol, because all the faces situated in the same manner being distinguished by the same letter in the figure, it is sufficient to point out that the symbol $^{5}G^{5}$ applies to the faces marked with the letter *o*, and this requires only to write the letter *o*, once under the symbol.

From the same principles, it follows, that the rhomboidal dodecahedron derived from the cube, Fig. 63. Pl. VI. is expressed by the symbol $\overset{1}{B}B$. The octahedron derived from the cube is expressed thus, $\overset{1}{A}\ {}^{1}A^{1}$.

The rhomboid, supposing it placed in the most natural aspect; that is to say, so that the two solid angles composed

* This figure represents a variety of the topaz; of course, our supposition respecting the primitive crystal is not accurate. But that does not injure the illustration.

ed of three equal plane angles, are in the same verti- line, has, properly speaking, no base, but merely sum- ts, which are the extremities of its axis. Its angles d edges are marked as in Fig. 67. Pl. VI. The letter lenotes that the angle marked by it is similar to that hich is marked with a capital E. So that if all the la- ral angles were indicated by letters, the three nearest e superior summit, would have the letter E, and e three nearest the inferior summit the letter *e*.

As the rhomboid has its six faces equal and similar, it only necessary to consider the decrements relative to le of these faces; as, for example, the one which in the gure is marked P, because all the others are mere repe- tions of this. These observations suggest the following les: 1. The decrements which set out from the supe- ior angle A, or the superior edge B, will have the figure dicating the number of ranges placed below A and B. Those which set out from the lateral angles E will ave their figures situated at the side and towards the p of the same letter. 3. With respect to those which t out from the inferior angle *e*, or from the inferior edge), the figure will be placed above the letter *e* or D.

Suppose, for example, that Fig. 68. Pl. VI. represents he variety of calcareous-spar called *analogic* by Hauy, its ymbol will be $\overset{2}{e}\ \overset{2}{D}\ B$.

$$c\ r\ \overset{1}{g}$$

What has been said of the rhomboid is easily applied o the other primitive forms. But probably some illus- rations will be considered as necessary to make the sym- ols applied to them the more readily understood. On hat account we shall take a short review of each of hem.

Fig.

Fig.69. Pl. VI. represents the octahedron with scalene triangles, Fig. 71. Pl VI. the octahedron with isosceles triangles, and Fig. 70. Pl. VI the regular octahedron.

In placing the figures which accompany the letters in the symbols, the same rule is followed that was described with respect to the rhomboid. Thus, in Fig. 70. Pl. VI. the figure is placed below the letter to represent the decrements setting out from the angle A or the edge B; it is placed above for those which set out from the edge D; and at the side, for those which set out from the angle E. If we want to denote the result of a decrement by one range upon all the angles of the regular octahedron, Fig. 71. Pl. VI. we have only to write $\overset{1}{A}\,{}^{1}A^{1}$. To indicate the result of a decrement by one range on all the edges, we write $B\,\overset{1}{B}$. The first of these decrements produces a cube, the second a rhomboidal dodecahedron.

In some species, as in the nitrate of potash, the primitive octahedron, the surface of which is composed of eight isosceles triangles, similar 4 and 4 to each other, ought to have the position represented in Fig. 72. Pl. VI. that the secondary crystals may have the most natural attitude; that is to say, that the edges which join the two pyramids which compose the octahedron, ought to be two of them in a vertical direction, as F, and two in a horizontal, as B. By comparing Fig. 71. Pl. VI. with Fig. 72 Pl. VI. in which the letters are placed as if all the angles and edges had different functions it will be easy to conceive the distribution adopted in Fig. 71. Pl. VI. and brought to the symmetry of the true primitive form. For, in the present case, we have E=A, D=C, G=F.

The

The figure denoting the number of ranges, will be placed under the letter, to denote decrements proceeding from B. It will be placed at one side, or below, to denote those proceeding from A; according as their effect respects the triangle AIA, or the triangle AIF. It will be placed above or below, for those which proceed from C, according as their effect is produced on the first or the second of these triangles. It will be placed at one side for the decrements which proceed from F. Finally, it will be placed above, below, or on either side, for the decrements that proceed from I, according as their effect takes place towards B or towards F.

The tetrahedron being always regular, when it becomes the primitive form, it will be expressed as in Fig. 74. Pl. VI. To indicate, for example, a decrement by three ranges on all the edges, we would write $B\overset{3}{B}$; and to indicate a decrement by two ranges upon all the angles, we would write $\underset{2}{A}\,{}^{2}A^{2}$, as in the case of the regular octahedron.

A simple inspection of Fig. 75. Pl. VI is sufficient to make us understand the symbols in the case of regular six-sided prisms. The figures are written precisely in the manner already described for the four sided prism; to which, therefore, we refer the reader. But it happens sometimes that three of the solid angles taken alternately are replaced by faces, while the intermediate angles remain untouched. In that case the prism is distinguished as in Fig. 76. Pl. VII.

In the rhomboidal dodecahedron, Fig. 77. Pl. VII. each solid angle composed of three planes may be assimilated to a summit of the obtuse rhomboid. Hence, it is only

 necessary

necessary to give letters to one face, as may be seen in the figure.

Hitherto there has been no occasion to use any symbols for the dodecahedron with triangular faces, because it is more natural to substitute in place of it the rhomboid from which it is derived, and which gives simpler laws of decrement.

We have still to explain the method of representing a peculiar case, which sometimes occurs in some crystals, where the parts opposite to those which undergo certain decrements remain untouched, or are modified by different laws. This case belongs chiefly to the tourmaline, and it is easy to indicate its peculiarity by means of zeros.

For example, in the variety of tourmaline represented in Fig. 79. Pl. VII. the primitive form of which is represented in Fig. 78. Pl. VII.; the prism, which is nine-sided, has six of its faces, namely, *s*, *s*, Fig. 79. Pl. VII. produced by the subtraction of one range upon the edges D, D, Fig. 78. Pl. VII. and the three others, such as *l*, by the subtraction of two ranges on the three angles *e*, Fig. 78. Pl. VII. only. Farther, the inferior summit has only three faces parallel to those of the nucleus; while, on the superior summit, the three edges B are replaced each by a face *n*, *n*, Fig. 79. Pl. VII. in consequence of a decrement which has not reached its limit. This crystal is represented by the following symbol: $\overset{1}{D}\,\overset{2}{e}\,\overset{2\cdot 0}{E}\,P\,\underset{1}{B}\,\underset{1\cdot 0}{b}$. The

$$\begin{matrix} s & l & & P & n \end{matrix}$$

quantities $\overset{2\ 0}{E}$, $\underset{1\ 0}{b}$ indicate, the one that the angles E, Fig. 78. Pl. VII. opposite to *e* undergo no decrement; the other, that the edges parallel to B remain equally untouched.

If

f these edges underwent a different law, which pro-
ed, for example, an abstraction of two ranges, the
ıbol would become $\overset{1}{D}\ \overset{2}{e}\ \overset{2.0}{E}\ P\ \underset{1\ 2}{B}\ b$. From this, it is
ious, that it must be understood that the decrements
resented by a capital letter accompanied by any fi-
e, do not implicitly include the similar decrements re-
sented by a small letter of the same name, or the op-
ite, that is to say, that $\overset{2}{B}$ does not implicitly include
or *vice versa*, except when the second letter does not
er into the symbol with a different figure, or does not
r the same figure accompanied by a zero. In the first
e, each of the two letters indicates a decrement which
ɔeculiar to the edge or angle indicated by it. In the
ond case, the zero indicates that the angle or edge to
ich it exclusively relates undergoes no decrement what-
r Thus, in the symbol $\overset{1}{D}\ \overset{2}{e}\ \overset{2.0}{E}\ P\ \underset{1\ 2\ 1}{B}\ b$, B expres-
a decrement by one range, which takes place only on
: edges contiguous to the superior summit A, Fig. 78.
VII.; $\overset{2}{b}$ indicates a decrement by two ranges, which
ly takes place on the edges contiguous to the inferior
nmit. The quantities $\overset{2}{e}$ and $\overset{2.0}{E}$ ought likewise to be
ısidered independent of each other; the first indica-
ıg a decrement of two ranges on the angles *e* only,
d the second indicating that no decrement whatever
kes place upon the angles E, opposite to the prece-
ng.

The foregoing observations have been given in consi-
rable detail, in order to put our readers completely in
ɔssession of the method, and to enable them to make a
figure

figure of a secondary crystal, merely from the symbol representing the laws of its formation. But to enable any person to read these symbols, and to understand them, much shorter directions would have sufficed. We shall subjoin the following rules, which will be sufficient for that purpose, and which will serve as a kind of epitome of the preceding observations:

1. Every vowel employed in the symbol of a crystal indicates a solid angle, marked with the same letter in the figure which represents the nucleus. Every consonant indicates the edge which has the same letter in the figure.

2. Each vowel and consonant is accompanied by a figure, the value and position of which indicate the law of decrement which the corresponding angle or edge undergoes. We must except the three consonants P, M, T; each of which, when it appears in the symbol of a crystal, indicates that the crystal has faces parallel to those faces which have the same letters on the figure of the nucleus.

3. Each letter contained in the symbol of a crystal, is understood, with the figure belonging to it, to apply to all the angles or edges which have the same function as it in the figure, and is marked with the same letter.

4. Every number joined to a letter indicates a decrement, setting out from the angle or the edge denoted by that letter. If the number is a whole number, it indicates how many ranges in breadth are subtracted, supposing each plate to have only the thickness of one molecule. If the number is a fraction, the numerator indicates the number of ranges subtracted in breadth, and the denominator the number of ranges subtracted in height

5.

. According as the number is placed below or above letter which it accompanies, it indicates that the de-ment descends or ascends, setting out from the angle edge marked by the letter. If it is placed towards : top, and either on the right or the left side of the let-, it indicates a decrement in a lateral direction, either the right or to the left of the angle or edge marked by e letter.

6. When a letter is twice repeated, with the same num-:r placed on two different sides, as $^2G\ G^2$ or $G^2\ {}^2G$, $A\ A^2$ or $A^2\ {}^2A$, the two edges, or the two angles hich it marks, ought to be considered on the figure in ie same relative positions; that is to say, for example, iat in the symbol $^2G\ G^2$, the quantity ^2G indicates the fect of decrement on the edge G situated at the left, and ie quantity G^2 the effect of decrement upon the edge ituated at the right.

7. When a letter has the same number both on the eft and the right side, as $^3G^3$, it applies equally to all he edges G. The same thing holds with the letters which belong to the angles.

8. The parenthesis, as for example $(\overset{3}{O}D^1\ F^2)$, indi-cates an intermediate decrement. The letter $\overset{3}{O}$ indicates, in the first place, that the decrement takes place by three ranges an the angle O, and that its effect is ascending. $D^1\ F^2$ indicate, that for one molecule subtracted along the edge D, there are two molecules subtracted along the edge F.

9. Every small letter occurring in the symbol of a crys-tal, indicates the angle or the edge diametrically oppo-site to that which has the capital letter of the same name in the figure, where the small letter is omitted as superfluous.

superfluous. We must except the letter *e*, which is always employed in the rhomboid, and which indicates, according to the principle, the angle opposite to that which bears the letter E.

10. When a symbol contains two letters of the same name, the one large the other small, with different numbers attached to them, the two opposite edges or angles to which these letters belong, are conceived to undergo each exclusively the law of decrement indicated by the number attached to the letter.

11. Every letter, whether large or small, marked by a number having a zero following it, indicates that the decrement denoted by that number does not take place on the particular edge or angle denoted by the letter.

7. *The Nomenclature of Crystals.*

In the Wernerian Crystallography, the different regular forms in general are expressed by short descriptions. Hauy, on the contrary, has attempted to designate them by names taken from the characters of the forms themselves, or from the properties that result from their structure, and from the laws of decrement on which they depend. In this manner he constructed the following nomenclature.

I. *Primitive Forms.*

When a crystallisation has the same figure as the primitive nucleus, and is therefore a primitive form, Hauy designates it, by prefixing to the name of the mineral the word *primitive;* for example, *Primitive Zircon, Primitive Calcareous-spar, Primitive Iron-pyrites.*

II.

II. *Secondary Forms.*

These may be considered under the following points of iew.

1. In relation to the modifications which the primitive form exhibits when its planes are associated with those originating from the laws of decrement.
2. Secondary forms, considered as purely geometrical forms.
3. In relation to certain planes or edges which are remarkable on account of their arrangement or position,
4. In relation to the laws of decrement on which they depend.
5. In relation to their geometrical properties.
6. Lastly, In relation to certain particular accidental circumstances.

1. *Secondary forms, considered in relation to the modifications which the primitive form exhibits, when its planes are associated with those resulting from the laws of decrement.*

A crystal is named

a. *Pyramidated (pyramidé)*, when the primitive form is a prism, and has a pyramid on each extremity, with as many planes as the prism has lateral planes. Example, Pyramidated apatite, (chaux phosphatée pyramidie,) Fig. 130. *System of Mineralogy* *.

and

* System of Mineralogy, edition 1816.

b. *Prismated* (prismé) when the primitive fo composed of two pyramids joined base to and the pyramids separated by a prism. amples, Prismated zircon (zircon prismé) F *Syst. Min.* and prismated quartz (quartz pri Fig. 66. *Syst. Min.*

c. *Semi-prismated* (semi-prismé) when only the of the edges on the common basis are oblite by lateral planes. Example, Semi-prismated phat of lead (plomb sulphaté semi-pris Fig. 241. *Syst. Min.* It is an elongated do four-sided pyramid, in which the two opp edges of the common basis are truncated.

d. *Based* (basé,) when the primitive form is eit double pyramid, or a rhomboid, in which summits are intercepted by planes perpendic to the axis, and which take the place of te nal planes. Example, Based sulphur (sc basé,) Fig. 150. *Syst. Min.* It is a do four sided pyramid, truncated on the extr ties.

e. *Epointé* *, when all the solid angles of the pr tive form are obliterated by single pla Example, Radiated zeolite mesotype epo It is a four-sided prism, deeply truncated o the angles; or, according to WERNER, a sided prism, acuminated on the extremities four planes, the acuminating planes set on lateral edges, and both the acuminations a truncated. The terms *bis-epointé*, *tri-ep* *quadri-epointé*, are used to express the a

t

* I here use the French word *epointé*, not recollecting any appro English term.

being intercepted by two, three or four planes. Examples:

Analcime tri-epointé, Fig. 79. Pl. VI. which is a cube acuminated on all the angles with three planes.

Fer sulphuré quadri epointé: which is a cube acuminated on all the angles, with three planes and the summits of the acuminations truncated.

f. *Emarginated*, (emarginée), when every edge of the primitive form, is intercepted by a plane or facet. Example, Emarginated garnet (grenat emarginé,) Fig. 58. *Syst. Min.* It is the garnet dodecahedron, truncated on all the edges. When each edge is intercepted by two or three small planes, the terms *bi-emarginated* (bis-emarginé), and *tri-emarginated* (tri-emarginé,) are used. Example, Tri-emarginated garnet (grenat tri-emarginé,) which is the rhomboidal dodecahedron bevelled on all the edges, and the bevelling edges truncated.

g. *Peri-hexahedral*, *peri-octahedral*, *peri-decahedral*, and *peri-dodecahedral*, when the primitive four-sided prism is changed by means of decrements into a six, eight, ten or twelve sided prisms. Crystals in which the primitive form is a regular six-sided prism, are also named *peri-dodecahedral*, when the six lateral planes are truncated. Examples, Peri-hexahedral blue vitriol or sulphat of copper, Pl. lxxii. Fig. 104. Hauy *, which

 is

* The Figures here referred to are those in Hauy's System of Mineralogy.

is an oblique four-sided prism, truncated on the obtuse lateral edges: Peri-octahedral blue vitriol or sulphat of copper, Pl lxxii. Fig. 105. HAUY, which is the oblique four-sided prism truncated on all the lateral edges: Peri-decahedral blue vitriol or sulphat of copper, Pl lxxii. Fig. 106. HAUY; the prism truncated on the obtuse lateral edges, and bevelled on the acute lateral edges: And peri-dodecahedral emerald, Fig. 35. *Syst. Min.* which is a six-sided prism truncated on all the lateral edges.

h. *Shortened*, (raccourci,) when the primitive form is a prism, whose bases are rhombs, in which the lateral edges contiguous to the great diagonal are intercepted by two planes, so that the primitive form appears to be shortened in the direction of its length. Example, Shortened heavy-spar, (baryte sulphatée raccourcie,) Pl. xxxv. Fig. 111. HAUY. It is an oblique four-sided table, very deeply truncated on the acute terminal edges; or, according to WERNER, a longish six-sided table.

i. *Narrowed*, (retreci,) when the primitive form is a prism, whose bases are rhombs, and in which the lateral edges contiguous to the small diagonal are intercepted by two planes, so that the primitive form appears to be diminished in the direction of its breadth. Example, Narrowed heavy-spar, (baryte sulphaté retrecie,) Fig. 142. *Syst. Min.* which is an oblique four-sided table deeply truncated on the obtuse terminal edges.

2. *Secondary*

Secondary Forms, considered in themselves as being purely Geometrical Forms.

A Crystal is said to be

a. Cubical, (cubique,) when it has the form of the cube, but which in this case is always secondary. Example, Cubical fluor-spar.

b. Cuboidal, (cuboide,) when the form varies very little from that of the cube, and is very slightly oblique. Example, Cuboidal calcareous spar, (chaux carbonatée cuboide), Pl. XXIII. Fig. 7. Hauy.

c. Tetrahedral, (tetraedre,) when the crystal has the regular tetrahedron as a secondary form. Example, Tetrahedral blende, (zinc sulphuré tetraedre).

d. Octahedral, (octaedre,) when it has the octahedron as a secondary form. Example, Octahedral rock-salt

e. Prismatic, (prismatique,) when it has the shape of a straight or an oblique prism, in which the lateral planes are inclined to each other, under angles of 120°. Example, Prismatic calcareous spar, (chaux carbonatée prismatique, Pl. XXIV. Fig 14. Hauy,) and prismatic felspar, (feldspath prismatique,) Fig. 92. *Syst. Min.*

f. Dodecahedral, (dodecaedre,) when its surface consists of twelve three-sided, four-sided, or five-sided planes, all of which are either equal and similar, or differ only in having two kinds of angles. Examples,

a. With

a. With twelve three-sided planes, (the double six-sided pyramid,) viz. rock-crystal, Fig. 67. *Syst. Min.*

b. With twelve rhomboidal or four-sided planes, as in the garnet dodechahedron. Example, Dodecahedral garnet. Fig. 56. *Syst. Min.*

c. With four six-sided, and eight four-sided planes, which is the four-sided prism acuminated on both extremities, with four planes, which are set on the lateral edges. Example, Dodecahedral hyacinth. Fig. 6. *Syst. Min.*

d. With twelve five-sided planes; the dodecahedron of Werner. Example, Dodecahedral common iron-pyrites. Fig. 186. *Syst. Min.*

g. *Icosahedral*, (icosahedre,) when its surface consists of twenty triangles, of which twelve are isosceles, and eight equilateral. Example, Icosahedral common iron-pyrites. Fig 192. *Syst. Min.*

h. *Trapezoidal*, when its surface consists of twenty-four equal and similar trapeziums: it is the double eight-sided pyramid, acuminated on both extremities with four planes, which are set on the alternate lateral edges. Example, Trapezoidal garnet (grenat trapezoidal). Fig. 57. *Syst. Min.*

i. *Tria-contrahedral* (tria-contraèdre), when its surface consists of thirty rhombs; it is the cube, in which each angle is so deeply acuminated with three planes, which are set on the lateral edges, that the lateral planes, and also the acuminating planes, appear as rhombs. Example, Tri-contra-

hedral

hedral common iron-pyrites, (fer sulphuré tri-contaedre). Fig. 194. *Syst. Min.*

Enneacontrahedral (ennéacontraèdre), when its surface consists of ninety faces. Example, Enneacontahedral vesuvian (idocrase enneacontraedre), Pl. xlvii. Fig. 74. Hauy.

Bi-rhomboidal, when its surface consits of twelve planes, which being taken six and six, and conceived to be elongated until they intersect, afford two different rhomboids: it is, according to the Wernerian view, an acute double three sided pyramid, in which the lateral planes of the one are set on the lateral edges of the other, and acuminated on both extremities by three planes, which are set on the lateral edges. Example, Bi-rhomboidal calcareous spar, (chaux carbonatée bi-rhomboidal), Pl. xxiv. Fig 13. Hauy.

We say in the same sense *tri rhomboidal*; this, in the Wernerian Crystallography, is a double six-sided pyramid, with alternately broad and narrow lateral planes, in which the broad planes of the one are so set on the narrow planes of the other; the planes pass beyond the common base, and the pyramid is acuminated on the extremities with three planes, which are set on the smaller lateral planes. Example, Tri-rhomboidal calcareous-spar, (chaux carbonatée tri-rhomboidal). Pl. xxv. Fig. 27. Hauy.

Bi-form, *tri-form* (bi-forme, tri-forme), when it contains a combination of two or three remarkable forms, such as the cube, the rhomboid, the octahedron, the regular six-sided prism, &c. Example,

Example, Tri-form alum (alumine sulphat
forme), Pl. xxxix. Fig 162. HAUY. It is a
four-sided pyramid, deeply truncated on
edges and angles, in which the truncating
on the edges originate from the garnet dod
dron, the truncations on the angles fro
cube, and the lateral planes from the o
dron.

n. Cubo-octahedral, cubo-dodecahedral, cubo-tetra
when it contains a combination of the two
indicated by these terms. Examples, Cub
hedral fluor-spar, which is the middle cryst
tween the cube and the octahedron in fluo
Fig. 135. *Syst. Min.* Cubo-dodecahedra
mon iron-pyrites, Fig. 185. *Syst. Min.*
the cubo-tetrahedral grey copper-ore, whic
simple three-sided pyramid, deeply trunca
all the edges, as Fig. 164. *Syst. Min.*

o. Trapezian, when its lateral surfaces consist o
pezia, which lie in two rows, between two
as in trapezian heavy-spar (baryte sulphat
pezienne). Fig. 140. *Syst. Min.* It is
angular four-sided table, bevelled on the
mities, where the bevelling planes are
ziums.

p. Di-tetrahedral, that is to say, twice tetral
when it represents a four-sided prism, be
on the extremities. Example, Di-tetra
tremolite, (grammatite di-tetraedre), Pl
Fig. 214. HAUY.

q. Di hexahedral (di-hexahedre), when it is a six
prism, having three planes on the extrem

Exa

Example, Di-hexahedral felspar (feldspath di-hexaedre), Fig. 95. *Syst. Min.* which is a broad six-sided prism, bevelled on the extremities, the bevelling planes set on two opposite lateral edges, and on each of the extremities, one of the angles, formed by the meeting of the bevelling planes with the lateral edges, and on which they are set, truncated.

In the same sense we say, *di-octahedral*, *di-decahedral*, & *di-dodecahedral*. Example, Di-octahedral topaz, Fig. 30. *Syst. Min.*; di-decahedral felspar; di-dodecahedral asparagus-stone, Fig. 131. *Syst. Min.* which is a six-sided prism, truncated on the lateral edges, and acuminated on the extremities with six planes.

r. *Tri-hexahedral*, *tetra-hexahedral*, *penta-hexahedral*, and *hepta-hexahedral*, (tri-hexaedre, tetra-hexaedre, penta-hexaedre, hepta-hexaedre), when its surface consists of three, four, five, or seven ranges of planes, disposed six and six above each other. Examples, Tri-hexahedral nitrate of potash, Pl. 38. Fig. 142. Hauy; which is a six-sided prism, acuminated on both extremities with six planes: penta-hexahedral amethyst, Fig. 65. *Syst. Min.* which is a six-sided prism, acuminated on both extremities with six planes, which are set on the lateral planes, and the edges between the acuminating and lateral planes truncated: hepta-hexahedral artificial nitrate of potash, Pl. xxxviii. Fig. 144. Hauy. which is a six-sided prism, acuminated on both extremities with six planes, which are set on the lateral planes, and the edges

between

between the acuminating and lateral planes be-
velled.

In the same sense we use the terms *tri-octahedral*
tri-dodecahedral; thus, tri-octahedral sulpha
of lead, Pl lxx. Fig. 76. Hauy, which is
four-sided pyramid, very much elongated, th
edges of the common base truncated, the angle
on it very deeply bevelled, the bevelling plane
set on the lateral edges, and the bevelling edge
again deeply truncated, so that the crystal, view-
ed in this way, consists of three rows of planes,
of which each row contains eight planes: it
may be more conveniently described as an oblique
four-sided prism: Tri-dodecahedral red silver-
ore, Pl. LXV. Fig. 19. Hauy. It is a six sided
prism, acuminated on the extremities with three
planes, and truncated on all the edges.

s. *Bi-geminated* (bi-géminé), when it exhibits a com-
bination of four forms, which, taken two and
two, are of the same species, such as the bigemi-
nated calcareous spar (chaux carbonatée bi-gé-
minée), Pl. xxvii. Fig. 49. Hauy; which i
an acute double six-sided pyramid, in which th
lateral planes of the one are set obliquely on th
lateral planes of the other, the angles on th
common base truncated, and flatly acuminate
on the extremities with three planes, which ar
set on the alternate lateral edges in an uncon
formable manner, and the edges which the acu
minating planes make with the lateral plane
truncated. It is a combination of two rhomboid
and two dodecahedrons.

t. *Amph*

t. *Amphi-hexahedral* (amphi-hexadre), that is to say, hexahedral in two senses, because by viewing the planes in two different directions, we obtain two six-sided surfaces, such as the amphi-hexahedral axinite (axinite amphi-hexaedre), Pl. 51. Fig. 107. Hauy, which is a rhomboid truncated in two opposite acute lateral edges, and also truncated on two of the diagonally opposite edges formed by the meeting of these truncating planes with the lateral planes

u. *Sex-decimal* (sex-decimal), when the planes that belong to the prism or the middle part of it, and those which belong to the two summits, are the one six, and the other ten in number, or *vice versa*. Example, sex-decimal felspar, Pl. 49. Fig. 86. Hauy, which is a six-sided prism, with five alterating planes on each extremity.

In the same manner, we say, *octo-decimal*, *sex-duodecimal*, *octo-duodecimal*, and *deci-duodecimal*. Examples, Octo-decimal artificial blue vitriol, Pl. 73. Fig. 109, Hauy, which is an oblique four-sided prism, deeply truncated on the obtuse lateral edges, slightly truncated on the acute lateral edges, bevelled in the two diagonally opposite edges formed by the acuter lateral edges with the terminal planes, and truncated on the other two: Octo-duodecimal artificial blue vitriol, Pl. 73. Fig. 113. Hauy; the preceding crystallisation, in which the edges between one bevelling plane and the terminal plane are again bevelled, so that there are on this place five small altering planes: Sex-duodecimal calcareous-spar, Pl. 25.

Hauy; which is a very acute double six-sided pyramid, with unconformable alternately obtuse and acute lateral edges, the lateral planes of the one set obliquely on the lateral planes of the other, and acuminated on both extremities with three planes, which are set on the acuter lateral edges; Deci-duodecimal felspar, Fig. 97.

x. *Peri-polygonal* (peri-polygone), when the prism has a great number of lateral planes, such as the peri-polygonal tourmaline, Pl. liii. Fig. 127. Hauy; which is a three-sided prism, bevelled on the lateral edges, the bevelling edges truncated, and the twelve edges formed in this way again truncated.

y. *Polysynthetic* (surcomposé,) when the form is very complicated, as in the polysynthetic tourmaline (tourmaline surcomposé), Pl. liii. Fig. 126. Hauy; which is a three-sided prism, bevelled on the terminal edges, the bevelling edges truncated; and acuminated on the one extremity with thre planes, on the other with six different kinds of planes, which together amount to nineteen.

z. *Anti-enneahedral* (antienneadre), when there are nine planes on the two opposite extremities of the crystal. This name belongs to a variety of tourmaline, Fig. 42. *Syst. Min.* in which there are nine alterating planes on each extremity, and the prism has twelve sides, in place of nine, the usual number.

a a. Prosenneahedral

a a. *Prosenneahedral* (prosenneadre); that is to say, having nine faces on two adjacent parts, as in the prosenneahedral tourmaline, Fig. 41. *Syst. Min.*; in which the prism has nine sides, and one of the extremities nine planes, and the other only three.

b b. *Recurrent* (récurrent), if, on reckoning the planes of the crystal in circular ranges from one end to the other, we have two numbers that succeed each other several times, as 4, 8, 4, 8, 4, as in recurrent tinstone (etain oxydé récurrent), Fig. 252. *Syst. Min.* which may be described as a rectangular four-sided prism, acuminated on the extremities with four planes, which are set on the lateral edges, and the eight edges formed by the acuminating and lateral planes truncated.

c c. *Equidifferent* (équidifferant), when the numbers which designate the faces of the prism, and those of the two extremities, which in this case differ from each other, form the beginning of an arithmetical progression, as 6, 4, 2. Example, Equidifferent basaltic hornblende, Fig. 110. *Syst. Min.*; which is a six-sided prism, acuminated on one extremity with four planes, on the other bevelled.

d d. *Convergent* (convergent), when in the preceding case the series converges rapidly, as 15, 9, 3. Example, Converging tourmaline, Pl. lii. Fig. 124. Hauy; which is a nine-sided prism, having fifteen planes on the one extremity, and on the other only three.

e e. *Unequal*

e e. Unequal (impair), when the numbers which designate the planes of the prism, and the planes of the two summits, which are sensibly different from each other, are all three unequal, without forming a progression. Example, Unequal tourmaline (tourmaline impair), Fig. 44. which is a nine-sided prism, having seven alterating planes on the one extremity, and three on the other.

f f. Hyper-oxide (hyper-oxyde); that is to say, uncommonly acute, as in the variety of calcareous-spar, which consists of two rhomboids, of which the one is acute and inverted, and the other much more acute, Pl. xxv. Fig. 30. Hauy.

g g. Spheroidal (spheroidal), when its surface consists of forty-eight convex faces, as in the diamond.

h h. Plano-convex (plano-convexe), when the faces are partly straight and partly uneven, as in the diamond.

3. *Secondary Forms considered in relation to certain Planes or certain Edges, which are remarkable for their arrangement or position.*

A Crystal is said to be

a. Alternate, (alterné), when it has upon its upper and under parts, faces that alternate with each other, but which correspond on both sides. Example, Alternate rock-crystal (quartz alterne), which is a six-sided prism, acuminated on both extremi-

ties with six planes, which are alternately small and large, and conformable.

c. *Bisalternate* (bisalterne), when, as in the preceding instance, an alternation takes place, not only among the faces of one and the same part, but also among those of the two parts. Examples, Bisalternate rock-crystal (quartz bisalterne), which is the preceding figure, but in which the larger and smaller acuminating planes alternate in an unconformable manner; Bisalternate calcareous-spar (chaux carbonatée bisalterne, Pl. xxv. Fig. 23. Hauy), which is an acute double six-sided pyramid, with unconformable and alternate obtuse and acute lateral edges, the lateral planes of the one set obliquely on the lateral planes of the other, so that the edge of the common basis forms a zigzag line; deeply truncated on the angles of the common base, and in such a manner, that the acute angles of the trapezoidal truncating planes, rest on the alternate acute lateral edges, and consequently are alternately turned towards the upper and under extremity of the pyramid.

e. *Bibisalternate* (bibisalterne), when there are two rows of bisalternate planes on each side, as in the bibisalternate cinnabar, Pl. lxv. Fig. 28. Hauy.

d. *Annular* or *ring-shaped* (annulaire), when a six-sided prism has six marginal faces or facets, disposed in a circular manner around each base. Examples, Annular emerald (emeraude annulaire), Fig. 38. *Syst. Min.;* annular tinstone (étain oxydé annulaire), which is a four-sided prism, truncated on all the edges and angles,

so

so that it appears like an eight-sided prism truncated on the terminal edges.

e. *Monostic* (monostique), when a prism with a determinate number of lateral planes, has a row of facets around each base, differing in number from those of the lateral planes, and all of which may be either on the terminal edges, or some on the terminal edges, and others on the angles. Example, Monostic topaz (topaz monostique), Fig. 31. *Syst. Min.* which is a slightly oblique eight-sided prism, in which two and two lateral planes meet under very obtuse angles; slightly truncated on the four terminal edges, formed by these lateral planes, and deeply truncated on the acute angles.

f. *Distic* (distique), when in a similar prism to the preceding, two rows of facets are arranged around each base. Example, Distic topaz (topaz distique, Pl. xliv. fig. 41. Hauy, which is the preceding eight-sided prism, in which the terminal edges, in place of being truncated, are bevelled, and the angles which the truncating planes of the acuter angles make with the acuter edges, also slightly truncated.

g. *Subdistic* (subdistique), when among the facets which are disposed in the same row around each base, there are two surmounted by a new facet, which is as it were the rudiment of a second row. Example, Subdistic crysolite, (krisolit subdistique), Fig. 121. *Syst. Min.* which is a very broad four-sided prism, acuminated on both extremities with four planes, which are set on the lateral planes; the apex of the acumination

which

which terminates in a line, truncated; also the lateral and acuminating edges, and the edges between the small acuminating planes, and the truncating planes of the acumination.

Plagihedral or *diagonal planed* (plagiedre), when it has facets which are situated obliquely. Examples, Plagihedral or diagonal planed rock-crystal, (quartz plagiedre), Fig. 69 *Syst. Min.* which is a six-sided prism, acuminated on both extremities with six planes, which are set on the lateral planes, truncated on all the angles, and the trapezoidal truncating planes set on obliquely.

Unsymmetrical (dissimilaire), when two ranges of facets situated one above another, on each extremity, exhibit a want of symmetry. Example, Unsymmetrical topaz (topaze dissimilaire), Pl. xliv. Fig. 42. Hauy, which is the distic topaz, with this difference, that the second slight truncations of the angles are wanting; but in place of them the edges formed by the meeting of the larger truncating planes of the acute angles with the bevelling planes, are slightly truncated.

Encadré or *framed*, when it has facets which form kinds of frames or squares around the planes of a more simple form already existing in the same species. Example, Framed or squared fluor-spar (chaux fluatée encadré), Fig. 138. *Syst. Min.* which is a cube truncated or bevelled on all its edges.

Blunt-edged (prominule), when its edges are very obtuse. Example, Flat-edged selenite (chaux sulphaté prominulé), Pl. xxxiv. Fig. 99. Hauy.; which is a twin-crystal, under the form of an eight-

eight-sided prism, acuminated with four planes, but of which two and two meet under such obtuse angles, that the edges are scarcely discernible, and the acumination has the appearance of a mere bevelment.

m. *Zoned* (zonaire), when a row of facets is arranged around the middle part, thus forming a kind of zone or girdle. Example, Zoned calcareous-spar (chaux carbonatée zonaire), Pl. xxvi. Fig. 39. Hauy, which is an acute double three-sided pyramid, in which the lateral planes of the one are set on the lateral edges of the other; the edge of the common basis truncated, and the angles of the basis bevelled.

n. *Apophanous* (apophané), when certain faces or edges offer some indications which assist us in determining the position of the primitive nucleus, which otherwise would be detected with difficulty, or even for determining either the direction or the measure of the decrements. Examples, Apophanous felspar (feldspath apophané), Pl. xlix. Fig. 89. which is the didecahedral variety of felspar, without the truncation and the angles between the bevelling planes and the lateral edges, but truncated on the edges of the bevelment. These last-mentioned truncating planes are inclined to one of the bevelling planes under a less angle, than to the other, which leads to the remark, that the first bevelling plane belongs to the primitive nucleus, which otherwise would have been difficult to determine, on account of the nearly equal inclination of the two bevelling planes: Apophanous red silver-ore (argent antimonié

timonie sulphuré apophane), Pl. lxiv. Fig. 13. Hauy, which is a very acute double six-sided pyramid, with unconformable alternating obtuse and acute lateral edges; the lateral planes of the one set obliquely on the lateral planes of the other, and flatly acuminated on the extremities with six planes which are set on the lateral planes. The edge of the common base, and the acuminating edges, correspond to the edges of the primitive rhomboid, by which the structure is revealed to the eye. Apophanous grey copper-ore (cuivre gris apophané), Pl. lxxv. Fig. 85. which is a simple three-sided pyramid, bevelled on all the edges, and acuminated on all the angles with three planes, which are set on the lateral planes: The bevelling and acuminating planes point out the decrements.

m. *Blunted* (emoussé), when it has facets which truncate certain parts of the crystal, which otherwise would be more prominent than the others. Examples, Blunted calcareous-spar (chaux carbonaté emoussé), Pl. xxvi. Fig. 40. which is the bisalternate variety of calcareous-spar, truncated on the acuter edges, by which the acute angle of the truncating planes on the angles of the common base is obliterated. Blunted axinite, Pl. li. Fig. 111. Hauy, which is the amphi-hexahedral variety of axinite, in which the two diagonally opposite edges, which the truncating planes of the acute edges form with the lateral plane, are bevelled.

n. *Contracted* (contracté), the name given to a dodecahedral variety of calcareous-spar, Pl. xxiv.

Fig. 20. HAUY, in which the base of the extreme pentagons experience a kind of contraction, in consequence of the inclination of the lateral planes. It is a six-sided prism, flatly acuminated on the extremities, with three planes, which are set on the alternate lateral planes in an unconformable manner. The lateral planes towards the ends of the crystal, where they are without acuminating planes and alternating, are broader, and somewhat inclined towards each other, and the acuminating planes are thereby somewhat diminished in size.

o. *Dilated* (dilaté), the name given to a variety of dodecahedral calcareous-spar, Pl. xxiv. Fig. 21. HAUY, in which the bases of the extreme pentagons are in some degree enlarged by the inclination of the lateral planes. It is the preceding figure in which the lateral planes at the ends where the acuminating planes rest upon them, are broader, and incline together, by which the acuminating planes are shortened.

p. *Acute-angular* (acutanglé), the name given to a prismatic variety of calcareous-spar, Pl. xxvi. Fig. 32. HAUY, in which the angles are replaced by facets which form very acute triangles. It is a six-sided prism, truncated on the angles; the truncating planes extend far down on the lateral edges, and are there very acute.

q. *Imperfectly facetted* or *defective* (defective), the name given to a variety of boracite, in which four of the angles of the primitive form are obliterated by facets, whilst the opposite angles remain untouched, so that there arises a certain degree of imperfection,

imperfection, Pl. xxxiii. Fig. 92. HAUY, which is a cube deeply truncated on all the edges, and on the alternate angles.

r. *Superabundant* (surabondante), the name given to another variety of boracite, where there are four facets, in place of each of the angles which were untouched in the former figures, so that there is a kind of superabundance in place of a deficiency, Pl. xxxiii. Fig. 93. HAUY. It is a cube deeply truncated on all the edges, feebly truncated on the alternate angles, but the other four angles are acuminated with three narrow planes, which are set on the lateral planes, and the apices of the acumination are again truncated.

Secondary forms, considered in relation to the Laws of Decrement from which they originate.

A crystal is named

a. *Unitary* (unitaire), when it experiences only a single decrement by one row. For example, the very acute double six-sided pyramid of sapphire, Fig. 25. *Syst. Min.* If there are three or four decrements by one row, we say *bisunitary*, *triunitary*, *quadriunitary*. Examples, Bisunitary, calcareous-spar, Pl. xxiv. Fig. 17. HAUY; Triunitary (triunitaire) chrysolite, Fig. 119. *Syst. Min.*

b. *Binary* (binaire), *bibinary* (bibinaire), *tribinary* (tribinaire), &c. when it experiences one, two, or three decrements by two rows. Examples, Binary calcareous spar, Pl. xxiv. Fig. 11. HAUY. Bibinary calcareous-spar, Pl. xxv. Fig. 26. HAUY.

c. *Ternary*,

c. *Ternary* (ternaire,) *Biternary* (biternaire,) &c. when it experiences one, two, or three decrements by three rows.

d. *Unibinary* (unibinaire), when two decrements occur, the one by one row, and the other by two rows. *Uniternary* (uniternaire), when there is one by one row, the other by three rows. *Binoternary* (binoternaire), when there is one by two, and the other by three rows. Examples, Uniternary calcareous-spar, and Binoternary calcareous-spar.

The nomenclature in all the preceding and following expressions has no reference to the planes which are parallel with those of the primitive nucleus, which exist most frequently in the secondary crystal. Among the forms in which the nucleus is entirely concealed, some have names borrowed from different considerations; and those which remain are so few in number, that Hauy thought it unnecessary to complicate the language, by employing a particular designation for them. In order to avoid confounding together those words that express the decrements with those that indicate the number of planes; the former have their termination in *hedral*, as dodecahedral, or in *al*, as octagonal, whereas the others end in *ary*.

e. *Equivalent* (equivalent), when the exponent which expresses one decrement, is equal to the sum of the exponents of the other decrements.

Example, Equivalent calcareous-spar,

$$\begin{matrix} \overset{2}{e}\,\mathrm{BA} \\ c\,\overset{1}{g}\,\overset{1}{0} \end{matrix}$$ Pl. xxv. Fig. 28. *Hauy.*

f. *Subtractive*

Subtractive (soustractif), when the exponent in relation to one decrement is less by one than the sum of those that indicate the others. Example, Subtractive calcareous spar, $\overset{2}{e}\,\overset{2}{\mathrm{D}}\mathrm{B}$, Pl. xxvi. f. 37.
$c\ r\ \overset{3}{t}$.

Additive (additif), when the exponent of the one decrement is greater by one than the sum of the exponents of the others. Example, additive straight lamellar heavy-spar, $\begin{matrix}\mathrm{M}^5 & \mathrm{H}^{51} & \mathrm{H}^1 & \overset{2}{\mathrm{A}} & \overset{1}{\mathrm{E}} & \mathrm{P}\\ \mathrm{M} & t & s & d & o & \mathrm{P}\end{matrix}$
Pl. xxxvi. Fig. 117. Hauy.

Progressive (progressif), when the exponents form the beginning of an arithmetical series, as 1, 2, 3. Example, Progressive calcareous spar, $\mathrm{E}^1\ {}^1\mathrm{E}\ \overset{2}{\mathrm{D}}\ \overset{3}{e}$, Pl. xxvii. Fig. 41. Hauy.
$f\ r\ m$

Interrupted or *disjunctive* (disjoint), when the decrements make a sudden spring, as from 1 to 4 or 6. Example, Disjunctive red-silver-ore, $\overset{1}{\mathrm{D}}\mathrm{PBB}$, Pl. lxv. Fig. 22. $n\ \mathrm{P}\ \overset{1}{s}\ \overset{4}{c}$

Partial (partial), when one part remains without decrements, while other similarly situated parts experience decrements. Example, Partial tin-white cobalt-ore, $\overset{2}{\mathrm{B}}\ \mathrm{E}^{\frac{1}{2}}\ {}^{\frac{1}{2}}\mathrm{EM}$, Pl. lxxviii. f. 167. Hauy.
$\overset{1}{e}\quad r\quad \mathrm{M}$

Semidouble (soudouble), when the exponent which belongs to one decrement, amounts to half the sum of the other decrements. Example, Semidouble topaz, $\begin{matrix}\mathrm{M}^2 & \mathrm{G}^2 & \mathrm{G}^3 & \overset{2}{\mathrm{B}} & \overset{2}{\mathrm{E}} & \mathrm{P}\\ \mathrm{M} & u & l & o & n & \mathrm{P}\end{matrix}$, Pl. xliv. Fig. 40. Hauy.

In

In the same manner we say, *Semitriple* (soutriple), *Semiquadruple* (souquadruple), &c.

m. *Doubling* (doublant), *tripling* (triplant), *quadripling* (quadriplant), when one of the exponents is repeated two, three, or four times, in a series which otherwise would have been regular. Examples, Doubling crysolite (peridot doublant).

$$\begin{array}{l} M^2\ GG^2\ {}^4GG^4\ T\overset{1}{C}\overset{1}{A}\overset{\frac{1}{2}}{B}P \\ M\ .\ s\quad z\quad T\,d\,e\,k\,P \end{array}$$ Fig. 123. *Syst. Min.*

Quadrupling crysolite, (peridot quadruplant),

$$\begin{array}{l} \overset{1}{M}\overset{1}{G}\ {}^2GG^2\ T\overset{1}{C}\overset{1}{A}\overset{\frac{1}{2}}{B}\ \overset{1}{B}P \\ M\,n\quad s\quad T\,d\,e\,k\quad n\,P \end{array}$$, Fig. 124. *S. M.*

n. *Identic* or *identical* (identique), when the exponents of two simple decrements are equal to the members of a fraction, which expresses a third and mixed decrement. Example, Identical grey copper-ore,

$$\begin{array}{l} PB\overset{5}{B}A^2\ A^2\ A^{\frac{2}{3}}\ A^{\frac{2}{3}} \\ \overset{5}{P}\ l\ ^2\quad o\quad \frac{2}{3}\ r \end{array}$$, Pl. lxxi. Fig. 89.

o. *Isonomous* (isonomé), that is to say, *equality of laws;* when the exponents which indicate the decrements on the edges, are equal to each other, and also those which indicate the decrements in the angles. Example, Isonomous artificial blue vitriol,

$$\begin{array}{l} {}^1G^1\ M^1\ H^1\ TP^2\ E\overset{1}{I}\overset{1}{G} \\ r\ M\ n\ TP\ s\,y\,u \end{array}$$, Pl. lxxiii. Fig. 108.

HAUY.

p. *Mixed*

Mixed (mixte), when the form results from a single mixed decrement. Example, Mixed sapphire $\overset{\frac{5}{2}}{\underset{n}{B}}$ Pl. xlii. Fig. 22. HAUY.

Pantogenous (pantogene), that is to say, which derives its form from all parts of the crystal, when every edge and angle suffers a decrement. Example, Pantogenous heavy-spar,

$$\begin{matrix} {}^{1}G^{1} & M^{1} & H^{1} & \overset{2}{A}\overset{1}{E}\overset{\frac{1}{2}}{B}P \\ k & M & s & d\,o\,z\,P \end{matrix}, \text{ Pl. xxxvi. f. 118. HAUY.}$$

Biferous (bifere), when every angle and edge suffers two decrements. Example, Biferous grey copper-ore.

$$\begin{matrix} P & \overset{1}{B}\overset{5}{B}BBA^{2} & A^{2} & A^{1} & A^{1} \\ P^{1} & f^{5}\ l^{2} & o & 1 & e \end{matrix}$$

Surrounded (entouré), when the decrements occur on all the edges and solid angles around the common basis of a prismatic nucleus. Example, Surrounded (entouré) celestine,

$$\begin{matrix} M\overset{\frac{1}{2}}{B}E\overset{2}{A}B \\ M\,z\,o\,d\,P \end{matrix}, \text{ Pl. xxxvi. Fig. 126. HAUY.}$$

Opposite (opposite), when one decrement is made by one row, and another is intermediate. Example, Opposite tinstone,

$$\begin{matrix} M \\ M \end{matrix}\left(\begin{matrix} \overset{\frac{1}{3}}{A}B^{1}\ B^{5} \\ z \end{matrix}\right)B^{1}, \text{ Pl. lxxx. f. 183. HAUY.}$$

Synoptic (synoptique), when the laws of decrement which occur in all the other Crystals of the same species, or at least in the greater number of them,

them, are united in this crystal. Example, Synoptic felspar.

$$\begin{matrix} G^2 & G^4 & M^2 & HT\overset{1}{I}\overset{2}{I}\overset{3}{I}P\overset{1}{D}\overset{1}{C}\overset{2}{I}^{\frac{1}{2}}\,I \\ l & z & M & \overset{1}{z}\,T\,x\,y\,q\,P\,n\,n\,\overset{1}{o}\,\overset{1}{o} \end{matrix}, \text{ Pl. xlix. fig. 90.}$$

x. *Retrograde* (retrograde), the name given to a variety of calcareous-spar, whose symbol or formula is $\left(\begin{matrix} \overset{9}{e}\,e & \overset{\frac{1}{3}}{B} \\ k\,l & \overset{1}{g} \end{matrix}\right)$ contains two mixed decrements, which are of such a nature, that the resulting faces seem to retrograde, by throwing themselves backward on the side of the axis opposite to that which looks towards the face on which they originate.

y. *Ascending* (ascendant), when all the laws of decrement have an ascending course, in departing from the angles or lower edges of a rhomboidal nucleus. Example, Ascending calcareous spar, $\begin{matrix} \overset{2}{e}\,\overset{3}{e}\,\overset{4}{D} \\ c\,m\,n \end{matrix}$, Pl. xxvii. Fig. 44.

5. *Secondary Forms, considered in relation to their Geometrical Properties.*

A crystal is named

a. *Equiangular* (isogone), when planes occurring on differently situated places, form among themselves equal angles. Example, Equiangular chrysoberyl, Pl. xliii. Fig 28. Hauy.

b. *Anamorphic* (anamorphique,) that is to say *inverted shape*, when we cannot give it the most natural position without the nucleus appearing as it were

were reversed. Example, Anamorphic stilbite or foliated zeolite, Fig. 76. *Syst. Min.* When we view this crystal as an unequiangular six-sided prism, truncated on the angles of the two most obtuse lateral edges, the shape of its nucleus, in comparison with the position it has in the dodecahedral variety of stilbite, appears reversed.

c. *Rhombiferous* (rhombifere,) when certain planes are true rhombs, although, from the manner in which they are cut by the neighbouring planes, they at first sight appear to have no symmetrical figure. Example, the Rhombiferous rock-crystal, Fig. 68. *Syst. Min.* which is a six-sided prism, acuminated on both extremities with six planes, which are set on the lateral planes, and slightly truncated on the alternate angles; the truncating planes are rhombs.

d. *Equiaxe* (equiaxe,) when it has the shape of a rhomboid, in which the axis is equal to that of the primitive rhomboid. Example, the Equiaxe calcareous-spar, Pl. xxiii. Fig. 2. Hauy, which is a very flat double three-sided pyramid, or it may also be viewed as a very flat rhombus, in which the axis is equal to that of the included nucleus.

e. *Inverse* or *inverted* (inverse,) when it has the form of a rhomboid, the solid angles of which are equal to the plane angles of the primitive rhomboid, and *vice versâ*. Example, Inverted calcareous-spar, Pl. xxiii. Fig. 31. Hauy.

f. *Metastatic* (metastatique,) that is to say *transferred*, when its plane angles and solid angles are

 the

the same as those of the nucleus, and are thus transported to the secondary form. Example, Metastatic calcareous-spar, Pl. xxiii. Fig. 4. Hauy, which is an acute double six-sided pyramid, with unconformable and alternating acuter and obtuser lateral edges; the lateral planes of the one set obliquely on the lateral planes of the other, so that the edge of the common base forms a zigzag line. The obtuse angle formed by the edges of the common base and the acuter lateral edges, is equal to the obtuse angle of the primitive rhomboid. The acuter lateral edges are equal to the lateral edges of the nucleus that lie in one and the same apex. These two angles, therefore, are as it were transported from the primitive nucleus upon the secondary crystal.

g. *Contrasting* (contrastant,) when it has the form of a very acute rhomboid, in which there is an inversion of angles similar to that which takes place in the *inverse*, exhibiting a kind of contrast, because it in so far resembles in another part a very obtuse rhomboid. Example, Contrasting calcareous-spar, Pl. xxiii. Fig. 5. Hauy.

h. *Fixed-angular* (persistant,) is the name of a variety of calcareous-spar, in which certain planes are so cut by the neighbouring planes, that their angles retain the same magnitude, which they would otherwise have had, only that the respective positions of these angles are changed. Example, Fixed-angular (persistant) calcareous-spar, Pl. xxv. Fig. 29. Hauy, which is a six-sided prism very acutely acuminated on both extremities, with three planes, which are set on the alternate lateral

ral planes in an unconformable manner, and the summits of the acuminations deeply truncated. The angles of the acuminating planes are equal to the angles of the rhombus of the inverse variety, and the angles of this latter variety have also remained, notwithstanding the change of form it has experienced by new or alterating planes.

i. *Analogic* (analogique,) when its form exhibits many remarkable analogies. Example, Analogic calcareous-spar, Pl. xxvi. Fig. 34. Hauy, which is a very acute double six-sided pyramid, in which the lateral planes of the one are set obliquely on the lateral planes of the other, and the zigzag edge of the common base so deeply truncated, that the truncating planes touch each other, and also the acuminating planes, in a point, and very flatly acuminated on the extremities with three planes, which are set on the alternate lateral edges.

k. *Paradoxical* (paradoxale,) when its structure exhibits very remarkable and unexpected results. Example, Paradoxical calcareous-spar, Pl. xxvii. Fig. 42. Hauy, which is the metastatical variety of calcareous-spar bevelled on the acuter edges, and acuminated on both extremities with three planes, which are set on the obtuse lateral edges.

l. *Complex* (complex,) when its structure is complicated by uncommon laws; as when it is formed partly by mixed, partly by intermediate decrements. Example, Complex calcareous-spar, Pl. xxvii. Fig. 43. Hauy, which is the inverse variety,

riety, when we consider it as an acute double three-sided pyramid, bevelled on the edge of the common base, and also truncated on its angles.

6. *Secondary forms, considered in regard to certain particular circumstances.*

A crystal is denominated

a. *Transposed* (transposé,) when it is composed of two halves of an octahedron, or of two portions of another crystal, of which the one appears to be turned upon the other a sixth part of its circumference. Example, Twin-crystal of spinel, Fig. 16. *Syst. Min.*

b. *Hemitrope* (hemitrope,) that is, *one-half turned round*,) when it is composed of two halves of one and the same crystal, of which the one-half appears to be turned round. Example, Twin-crystal of felspar.

c. *Rectangular* (rectangulaire,) the name of a variety of grenatite, which consists of two prisms that intersect each other at right angles, Fig. 63. *Syst. Min.*

d. *Oblique-angular* (obliquangle,) the name applied to the variety of grenatite when two prisms cross each other at an angle of 60°, Fig. 64. *Syst. Min.*

e. *Six-radiated* or *stellular intersecting* (sexradié,) a name given to a variety of grenatite, composed of three prisms, that intersect each another in such a manner, as to represent the six radii of a regular hexagon.

f. Cru-

f. Cruciform (cruciforme,) when it is composed of two crystals which form a kind of cross, as in cross-stone, Fig. 86. *Syst. Min.*

g. Alternately streaked (triglyphé,) when the striæ viewed upon three faces around the same solid angle, are in three directions, and perpendicular to each other. Example, Common iron-pyrites, Pl. lxxvi. Fig. 141. HAUY.

h. Geniculated (geniculé,) when it is composed of two prisms, which are united at one end, and form a kind of knee. Example, Geniculated rutile, Fig. 218. *Syst. Min.*

IV. *Etraneous External Shape.*

Extraneous External Shapes of Minerals are those derived from organic bodies. They are also named *petrifactions*, and less properly *fossils*. The particular study of these interesting forms belongs to Geognosy, as the oryctognost views them only in a general way. In the prefixed Tabular View, they are arranged in the order in which the originals are described in the natural history of organic bodies, and are first divided into Petrifactions from the Animal Kingdom, and into those from the Vegetable Kingdom *.

A.

* In describing petrifactions, with the view of a complete history of the species, a more regular and comprehensive arrangement ought to be followed than that usually employed by naturalists. In a paper which I read before the Wernerian Society some years ago, I proposed and adopted the following

A. Petrifactions from the Animal Kingdom.

a. Quadrupeds. The fossil remains of quadrupeds are generally found but little altered, and in single pieces, as *bones*, *teeth*, and *horns*; seldom in complete skeletons. The greater number of species found in this state appear to be extinct *.

b. Birds. The remains of birds, which are usually single bones, feet, claws, and bills, are very rare; they have been found in the vicinity of Mont Martre near Paris, and in the limestone of Æningen and Pappenheim.

c. Amphibious animals. Fossil remains of tortoises and crocodiles have been met with in different parts of Europe. Fossil tortoises occur in the Isle of Shepey in the Medway; and fossil remains of animals allied to the crocodile are met with in the neighbourhood of Bath, in the cliffs on

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following arrangement, in describing a petrifaction from Sicily. 1. Description of the external aspect and internal structure. 2. Chemical characters, and chemical composition. 3. Geognostic situation. 4. Geographic situation. 5. Uses. 6. History, under which head I include all that is known of the first discovery of the petrifaction, the names it may have had at different times, the different figures and descriptions of it published by authors, and other information of a miscellaneous nature.

* It may be remarked, that the fossil remains of the Human Species rarely occur; the only well-authenticated example of this kind being the human skeleton imbedded in an alluvial calcareous mass brought from Guadaloupe by Sir Alexander Cochrane, and now in the British Museum; nor should the rarity of their occurrence excite our wonder, when it is recollected, that human bones are looser in their texture, and more cellular than those of quadrupeds, and therefore much more liable to decomposition.

on the Dorsetshire coast, and also on the coast of Yorkshire.

d. *Fishes.* Of these we find petrified either the *entire fish, skeletons, vertebræ,* or *teeth.* Of the entire fish instances have been observed in the copper or marl slate of the county of Mansfeld; and also in Oxfordshire, Gloucestershire, Leicestershire, Lincolnshire, Dorsetshire, and Kent *; of the skeletons in the limestone of Pappenheim; of the vertebræ in Shepey; of the teeth, particularly those of the shark, considerable quantity in the Island of Malta, and also in Kent, and Isle of Shepey.

e. *Insects.* These are very rare. The only well authenticated instances of petrified fresh water insects are the larvæ of libellulæ found in the limestone of Pappenheim. Of sea insects a very considerable variety have been discovered. Of the genus cancer several distinct species have been found in the Isle of Shepey in the Medway.

Insects inclosed in amber are not to be regarded as petrifactions, because they are dead bodies nearly unaltered.

f. *Shells.* Many genera of fossil shells are enumerated in the Tabular View, of which a particular account will be given in one of the volumes of my *System of Mineralogy.* It is sufficient for our present purpose to remark, that these fossil remains are uncommonly numerous, and are for the

* Parkinson's Organic Remains, vol. iii. p. 249.

the most part of a species which have never been found in a living state.

g. Crustaceous animals. Of these the most remarkable and abundant are the Echinites, and Asterites.

h. Corals. Many different fossil genera and species of these bodies have been figured and described by naturalists, under the names *madreporites, milleporites, fungites,* &c.

B. Petrifactions from the Vegetable Kingdom.

These are,

a. Impressions of plants and leaves. These occur very frequently, and appear to characterise particular formations. Thus the impressions and casts of reeds and ferns appear to occur most frequently in the bituminous shale and slate-clay of the coal formation. Petrifactions of seeds and fruits also occur in sandstone and other rocks.

b. Transmuted wood, or *petrified wood.* It occurs in the form of trunks, branches or roots. The wood is either petrified with an earthy mineral, as in wood-stone and wood-opal; with a metalliferous mineral, as in pyritical wood; or it is bituminous, as in the different kinds of brown-coal *.

II.

* The best English work on Petrifactions is that of Mr Parkinson, entitled "Organic Remains of a Former World." It abounds in curious and important information, and is adorned and illustrated with numerous beautiful plates. Mr Sowerby is publishing a useful work entitled *Mineral Conchology.* And the valuable observations on organic remains, in the Transactions of the Geological Society of London, are further proofs of the general attention now bestowed on the natural history of petrifactions.

II. *The External Surface.*

e external surface of minerals is either smooth, or or less uneven. When the inequalities become so as to affect the shape, they are no longer consider- characterising a variety of surface, but as a variety ernal form.

e following are the varieties of this character.

Uneven. This, of all the kinds of external surface, presents the greatest and most irregular elevations and depressions, yet they are not so considerable as to alter the external shape. Example, Balls of calcedony.

Granulated. When the surface is composed of numerous small nearly similar roundish elevations, that appear like grains strewed over it, it is said to be granulated. It has a striking resemblance to shagreen. It is either *coarse* or *fine* granulated. The first occurs in reniform brown hematite, also in compact brown ironstone; the latter in diamond grains, and sometimes also in crystals of diamond.

Rough. This kind of surface is marked with small scarcely visible elevations, which we can hardly discover but by the feel. It has little or no lustre. Examples, Rolled pieces of common quartz and rock crystal.

Smooth. Here there is no perceptible inequality, and the surface reflects more light than the preceding kinds of external surface. Examples, Fluor-spar, cubes of galena or lead glance, and the acuminating planes of rock-crystal.

5. *Streaked.* This kind of surface is marked with line-like elevations. It is either *simply streaked* or *doubly streaked.*

A. *Simply streaked*, when the linelike elevations run but in one direction.

a. *Longitudinally streaked.* When the streaks are parallel with the length of the lateral planes. Examples, Topas, schorl, and beryl.

b. *Transversely streaked.* When the streaks are parallel with the breadth of the lateral planes. Examples, Rock-crystal and quartz.

c. *Diagonally streaked.* Where the streaks are parallel with the diagonal of the planes. We have an example of it in the garnet, where the streaks pass through the obtuse angle of the rhomboid.

d. *Alternately streaked.* When transverse and longitudinal streaks occur on alternate planes. Examples, Cubic iron-pyrites and red ironstone.

B. *Doubly streaked*, when the streaks run in different directions. This is either

a. *Plumiformly.* When the streaks run obliquely towards a principal streak, like the disposition of the parts of a feather. We must be careful not to confound it with the plumose external shape. It occurs in the folia of Plumose native bismuth.

b. *Reticularly.* When the streaks either cross each other in a promiscuous manner, or under right angles, forming a kind of flat net-work. It occurs on the surface of silver-white cobalt-ore.

6.

6. *Drusy.* When a crystal is coated with a number of minute crystals of the same kind, so that the new surface acquires a scaly aspect, it is denominated drusy. Examples, Common iron-pyrites and common quartz.

III. *The External Lustre.*

Here we have to consider the *intensity* and the *sort* of re.

1. *The intensity of the lustre.* Of this there are five different degrees.

A. *Splendent.* A fossil is said to be splendent, when in full day light (not in the sunshine) its lustre is visible at a great distance. The highest degree of this is termed *specular splendent.* It generally occurs in minerals with a perfect foliated fracture. Galena or lead-glance, selenite, mica, and iron-pyrites, are good examples of this degree of lustre.

B. *Shining.* When a mineral at a distance reflects but a weak light, it is said to be shining. Examples, Heavy-spar, pitchstone, and common opal.

C. *Glistening.* This degree of lustre is only observable when the mineral is near us, and at no greater distance than arm's length. Examples, Grey copper-ore, porcelain jasper, common actynolite, and splintery quartz.

D. *Glimmering.* If the surface of a mineral, when held near to the eye in full and clear day light, presents a very great number of small faintly shining points, it is said to be glimmering. In strong sunshine it exhibits a kind of play of colour.

lour. As examples of this degree of lustre, we may mention clay ironstone, red hematite, compact galena or lead-glance, and porcelain jasper; and of faintly glimmering, Lydian-stone is a good example.

E. *Dull.* When a mineral does not reflect any light, or is entirely destitute of lustre, it is said to be dull. Example, Clay ironstone and chalk.

2. *The sort of lustre.* Of the different sorts of lustre we cannot give any definition, but must rest satisfied with mentioning a few minerals which present these characters in the greatest perfection.

a. *Metallic lustre*, is always combined with opacity. Examples, Copper pyrites, grey copper-ore, and lead-glance.

b. *Semimetallic.* Examples, White and yellowish-grey mica and red hematite.

c. *Adamantine.* It occurs in the diamond, particularly the white and grey varieties, and sometimes also in white lead-ore.

d. *Pearly*, as in kyanite, zeolite, and selenite.

e. *Resinous* or *waxy*, as in pitchstone, yellow lead-ore, and tinstone crystals.

f. *Vitreous* or *glassy*, as in rock-crystal and topaz.

In determining the lustre of minerals, we ought to expose them to a strong light, but not to the direct rays of the sun. The specimens should not be handled, a practice too often followed, and which very soon alters the lustre, or adds a lustre to such as have none.

IV. *The Aspect of the Fracture.*

Here we have to observe the *lustre* of the fracture, the *fracture*, and the *shape of the fragments.*

V.

V. *The Lustre of the Fracture.*

e internal lustre, or the lustre of the fracture, pre- the same varieties as the external lustre, and there- equires no particular description.

VI. *The Fracture.*

fracture we understand the shape of those internal es or planes of a mineral which are produced by ing or splitting it. These surfaces are either conti- , when the fracture is said to be *compact*, or are osed of a number of line-like or foliated parts, term- *tinct concretions*, when the fracture is named *split* or *d.*

. *Compact Fracture.* There are six different kinds of compact fracture, viz. *splintery*, *even*, *conchoidal*, *uneven*, *earthy*, and *hackly*.

a. Splintery. When, on a nearly even surface, small wedge-shaped or scaly parts are to be observed, which adhere by their thicker ends, and allow a little light to pass through, we say that it is splintery. It sometimes passes into even.

b. Even, is that kind of fracture-surface which shews the fewest inequalities, and these inequalities are flat and their boundaries never sharply marked, on the contrary, they run into each other imperceptibly. Minerals possessing this kind of fracture have generally a low degree of lustre and of transparency. It occurs in chrysoprase, calcedony, compact galena or lead-glance, compact red ironstone, and compact brown ironstone. It passes into large conchoidal and into splintery.

c.

c. *Conchoidal*, is composed of concave and convex roundish elevations and depressions, which are more or less regular: when regular, they are accompanied with concentric ridges, as in many shells, and hence present a conchoidal appearance. It is distinguished, according to the magnitude of the elevations and depressions, into *large conchoidal*, as in obsidian or flint, and into *small conchoidal*, as in pitchstone. The large conchoidal passes into Even, and the small conchoidal into Uneven. It is further distinguished, according to the depth of the inequalities, into *deep conchoidal*, as in rock crystal, and *flat conchoidal*, as in flint: and, lastly, according to perfection, into *perfect conchoidal*, as obsidian, or common opal, and into *imperfect conchoidal*, as porcelain jasper. Minerals shewing this kind of fracture exhibit almost every degree of lustre and transparency.

d. *Uneven*. This kind of fracture shews the most considerable elevations and depressions, and the elevations are usually angular and irregular. These elevations are denominated the *grain*; and, according to the size of the grain, the fracture is named *coarse grained*, as in copper-pyrites; *small grained*, as in copper nickel; or *fine grained*, as in arsenical pyrites.

This kind of fracture frequently occurs in minerals having some lustre, and which are opaque, and is most frequent in metallic minerals. It passes into small and imperfect conchoidal, and also into earthy.

e. *Earthy*. When the fracture surface shews a great number of very small elevations and depressions, which

which make it appear rough, it is called earthy. It is always associated with complete opacity and want of lustre, which latter character distinguishes it from the fine-grained uneven fracture. It is peculiar to earthy minerals. It is distinguished into Coarse earthy and Fine earthy. It passes sometimes into even, and sometimes into uneven. Examples, Chalk and clay ironstone.

Hackly. When the fracture surface consists of numerous small slightly bent sharp inequalities, which are sometimes only discoverable to the feel, it is said to be hackly. It occurs only in native malleable metals, and is, consequently, accompanied with metallic lustre and opacity. Examples, Native copper, native silver, &c.

These different kinds of compact fracture often run into each other, and frequently several occur together; in the latter case, the most prevalent fracture is the one which is to be taken as the characteristic one.

Split fracture *. Under this head we include what is called by some mineralogists the *Structure of Minerals.*

Three different kinds of split fracture are enumerated in the Tabular View, the *fibrous, radiated,* and *foliated.*

Fibrous fracture. In this kind of fracture the distinct concretions of which it is composed are so narrow, that the only magnitude which can be readily determined, by the naked eye, is the length; hence it is be considered as composed

* This is the *gespaltenen bruch* of the Germans; which I have translated *split fracture*, probably not a very appropriate translation, but I do not ber any less objectionable.

sed of line-like parts. It is never dull; on the contrary, it is generally glimmering or glistening, seldom shining, and never splendent. It sometimes occurs in transparent minerals, but oftener in those which are nearly opaque. The minerals in which it occurs are sometimes crystallised in capillary crystals. In the fibrous fracture we have to attend to the *thickness*, the *direction*, and the *position* of the fibres.

a. *Thickness* of the fibres.

α. *Coarse fibrous*, when the fibres are of a considerable thickness, as in common fibrous quartz, common asbestus, and fibrous gypsum.

β. *Delicate fibrous*, when the fibres are narrower than in the preceding variety, and occasionally so delicate, as to be scarcely visible to the naked eye. Examples of delicate fibrous fracture occur in red hematite, and fibrous malachite; and of extremely delicate fibrous fracture, in calc-sinter and amianthus.

The coarse fibrous fracture is the link which connects the fibrous with the radiated fracture.

b. The *direction* of the fibres.

α. *Straight fibrous*, as in red hematite and fibrous malachite.

β. *Curved fibrous*, as in asbestus and fibrous gypsum.

c. The *position*.

α. *Parallel fibrous*, when the fibres, whether straight or curved, are parallel to each other, as in common asbestus, and fibrous gypsum.

β. *Diverging fibrous*, when the fibres proceed from a common centre, in different directions; and this is either

i. *Stellular diverging*, when the fibres diverge in all directions, like the radii of a circle, as in brown hematite.

ii. *Fascicular* or *scopiform*, when the fibres diverge only on one side, so that the middle fibres are often longer than the lateral ones, as in malachite, fibrous zeolite, and reniform red hematite.

γ. *Promiscuous fibrous*, when the fibres cross each other in all directions, as in compact plumose antimony.

Radiated fracture. The distinct concretions in this kind of fracture, have two discernible dimensions, namely, in length and breadth, and of these the first is the most considerable. Hence the fracture surface exhibits long and narrow fracture parts, which sometimes rest on each other, or are placed side by side. The lustre alternates from splendent to shining, and the transparency from translucent to opaque. The minerals in which it occurs are sometimes crystallised either in needles, or in broad prisms. In the radiated fracture, we have to attend to the *breadth*, *direction*, *position*, and *cleavage* of the rays, and the *aspect* of the rays surface.

α. *The breadth of the rays.*

α. *Uncommonly broad radiated*, when the breadth of the rays is more than one-fourth of an inch, as is sometimes the case with radiated grey antimony-ore, and kyanite.

β. *Broad radiated*, when the breadth of the rays is less than the fourth of an inch, but not less

 than

than a line, as in common actynolite and mica.

γ. *Narrow radiated*, when the breadth extends from a line to one-fourth of a line, also in actynolite.

b. *Direction of the rays.*

α. *Straight radiated*, which is very frequent, as in actynolite.

β. *Curved radiated*, which is rare. The curvature is either in the direction of the *breadth*, as in common actynolite, or in the direction of the length, as in kyanite.

c. *Position of the rays.*

α. *Parallel radiated*, as in grey antimony-ore, and in common hornblende.

β. *Diverging radiated.*

i. *Stellular*, as in radiated red cobalt-ochre, or cobalt-bloom.

ii. *Scopiform*, as in radiated grey antimony-ore, and radiated zeolite.

γ. *Promiscuous*, as in hornblende slate, and grey antimony-ore.

d. *Cleavage or passage of the rays.*

a. *Single cleavage* which is generally the case.

b. *Double cleavage*, as in hornblende. In general the cleavage, of which a particular account will be given when treating of the foliated fracture, is imperfect, and we seldom can distinguish more than one variety of it, which is the single.

e. *The aspect of the rays surface.* The rays are either

α. *Smooth*, as in radiated grey antimony and actynolite.

β. *Streaked*, as in radiated grey manganese-ore and hornblende.

C. *Foliated fracture.* This kind of fracture is composed of folia or planes in which the length and breadth are nearly equal; which are shining or splendent, and superimposed on each other in various directions. It occurs in minerals possessing every degree of transparency, which are generally crystallised, and usually afford regular fragments. It is a more frequent fracture than either the radiated or fibrous.

In the foliated fracture, we have to attend to the *size of the folia*, the *degree of perfection of the foliated fracture*, the *direction of the folia*, the *position of the folia*, the *aspect of the surface of the folia*, and the *passage of the folia*, or *cleavage*.

a. *The size of the folia.* The size of the folia is determined by that of the distinct concretions; so that a mineral which is composed of large granular concretions, must have a large foliated fracture, or, of small granular concretions, a small foliated fracture. When a mineral with a foliated fracture is not composed of distinct concretions, but is one uniform undivided mass, the folia pass uninterruptedly through the whole extent of the mass, and afford the largest variety of foliated fracture.

b. *The degree of perfection of the foliated fracture.* This depends on the facility with which the folia

lia are separated from each other by splitting, and also on the lustre, the smoothness of the fracture surface, and on the readiness with which we can determine the foliated fracture.

Thus it is

α. *Highly perfect*, or *specular splendent:* When the folia are perfectly smooth, and specular splendent, as in galena or lead-glance, yellow blende, transparent calcareous-spar, and selenite.

β. *Perfect foliated*, in which the folia are pretty smooth, and shining, and sometimes splendent, as in mica and felspar.

γ. *Imperfect foliated*, when the folia are slightly uneven or even rough, and the lustre lower than in the perfect foliated, as in fluor-spar and beryl.

δ. *Concealed foliated*, when the folia are separated from each other with difficulty, and the foliated fracture appears only in a few places of the fracture surface, as in rock crystal.

c. *The direction of the folia.*

α. *Straight foliated*, as in selenite and calcareous spar.

β. *Curved foliated*, which is either

I. *Spherical curved foliated*, when the folia are so bent, that they resemble either whole spheres or segments of spheres, as in brown-spar and mica.

II. *Undulating curved foliated*, when the folia are so laid over each other, that a transverse section gives a serpentine line, but the longitudinal one a straight line, as in mica.

III.

III. *Florifom foliated*, when the folia are variously curved, and the curvatures are arranged in a scopiform manner, as in galena or lead-glance.

IV. *Indeterminate curved foliated*, when the folia are irregularly or indeterminately curved, as in iron mica or micaceous iron-ore, and mica.

d. *The position of the folia.*

α. *Common foliated*, when the folia extend throughout the whole mass, and cover each other completely, as in calcareous-spar, and most other minerals with a foliated fracture.

β. *Scaly foliated*, when the folia cover each other only partially, in their arrangement somewhat resembling the scales on a fish. It is divided into *large*, *small*, and *fine* scaly foliated, and occurs in mica.

e. *The aspect of the surface of the folia.* The foliated fracture is either

α. *Smooth*, as in calcareous-spar and felspar: or,

β. *Streaked*, which is either

I. *Simply streaked*, and in the direction of the length, as in common hornblende.

II. *Variously streaked*, as in iron-mica.

III. *Plumosely streaked*, as in mica.

f. *The passage of the folia* or *cleavage.*

The cleavage is the number of determinate directions in which a mineral exhibits a foliated fracture, and according to which it can be split.

It

It is distinguished

α. *According to the number of the cleavages.*

i. *Single*, when it splits only in one direction, as in mica.

ii. *Twofold* or *double*, when it splits in two directions, as in felspar, hornblende, and tremolite.

iii. *Threefold* or *triple*, when it splits in three directions, as in calcareous-spar, rock salt, and galena or lead-glance.

iv. *Fourfold* or *quadruple*, when it splits in four directions, as in fluor-spar, specular iron-ore, or iron-glance, and beryl.

v. *Sixfold*, when it splits in six different directions, as in blende and rock crystal.

β. *According to the angle under which the cleavages intersect each other*; and these exhibit the following varieties,

i. In the *twofold cleavage*, the two folia or cleavages intersect each other *rectangularly*, as in felspar and hyacinth; or *oblique angularly*, as in hornblende.

ii. In the *threefold cleavage*, the folia intersect each other *rectangularly*, as in galena or lead-glance; *oblique*, yet *equiangularly*, as in calcareous-spar and sparry ironstone; *oblique* but *unequiangularly*, as in heavy-spar; and partly *rectangularly*, partly *oblique-angularly*, as in selenite.

iii. In the *fourfold cleavage*, all the cleavages are *equiangular* and *oblique-angular*, as in fluor-spar, iron-glance, and diamond; or three cleavages are *equiangular* and *oblique-angular*,

lar, in a common axis, and are intersected by a fourth, which is horizontal and rectangular, as in beryl.

iv. In the *sixfold cleavage*, all the cleavages meet under *equal oblique angles*, as in rock-crystal; or three of the cleavages are *equiangular* and *oblique-angular* in a common axis, and are obliquely intersected by three others, which also intersect the axis in an oblique direction. Example, hornblende.

These angles of the various cleavages may also be more particularly measured by means of the goniometer.

Slaty fracture. This fracture, like the foliated, consists of plane-like portions, in which the length and breadth are nearly alike, but in which the thickness begins to be discernible. The fracture-surface is generally rough, with but little lustre. It is nearly allied to the foliated fracture, but is less perfect, and never occurs in regularly crystallised minerals, but always in those which are found in large masses, or in beds. Minerals with this fracture are generally opaque. This fracture is further distinguished according to *thickness*, *direction*, *perfection*, and *cleavage*.

a. Thickness.

a. *Thick slaty*, as in alum-slate, flinty-slate, and clinkstone.

b. *Thin slaty*, as in most of the varieties of clay-slate.

b. Direction.

a. *Straight slaty*, as in common clay-slate.

b. *Curved slaty*, which is either.

a a. *Indeterminate curved slaty*, as in some varieties of bituminous marl-slate.

b b. *Undulating curved slaty*, as in glossy alum-slate.

c. *Perfection.*

a. *Perfect slaty*, as in clay-slate.

b. *Imperfect slaty*, as in common flinty slate.

d. *Cleavage.*

a. *Single cleavage*, which is the usual variety in clay-slate.

b. *Double cleavage*, very rare, as in clay-slate.

2. *Where several fractures occur at the same time, their relative situation must be observed.*

A. *One including the other.*

In some minerals there occurs a double fracture, in which the one fracture is larger than the other, and includes it; the one, the larger fracture, is named the *fracture in the great*; the other the lesser, the *fracture in the small*; thus, whet-slate has in the great a slaty-fracture, but in the small a splintery fracture.

B. *One traversing the other.*

In other minerals, when the fracture also is double, but in which the length and breadth are different, that fracture which is in the direction of the length is named the *longitudinal fracture*: the other, in the direction of the breadth, the *transverse* or *cross-fracture*. Thus, in topaz, there is a conchoidal longitudinal fracture, and a foliated transverse or cross fracture. But in tessular crystals, where the length and breadth are nearly alike, we use, in place of the term *longitudinal*

tudinal fracture, principal fracture, and apply it to that fracture which occurs the most frequently in breaking a mineral; the other fracture, *the cross fracture*. Thus, in blende, the principal fracture is foliated, with a sixfold cleavage; the cross fracture conchoidal; and in drawing-slate, the principal fracture is slaty, and the cross fracture is earthy.

VI. *The Shape of the Fragments.*

ıgments are those shapes which are formed when eral is so forcibly struck or split, that masses having ınding fracture surfaces are separated from it.

e fragments are either *regular* or *irregular*.

Regular fragments, are inclosed in a certain number of regular planes, that meet under determinate angles. They occur only in such minerals as have a foliated fracture, with several cleavages. Each cleavage in these regular fragments, forms two opposite parallel planes, and the shape of the fragment depends on the number of these planes, and the magnitude of the angles under which they meet. Minerals with a twofold cleavage, do not afford perfect regular fragments, only prismatic fragments, surrounded with four regular lateral planes, as in hornblende. The following are the varieties of regular fragments.

A. *Cubic*, which occur in minerals possessing a rectangular threefold cleavage, as galena or lead-glance and rock-salt.

B. *Rhomboidal* or *oblique-angular*, which occur in minerals having a threefold cleavage, as calca-

 reous-spar.

reous-spar. When two cleavages intersect each other obliquely, and are intersected rectangularly by a third, the fragments are oblique angular in one direction, and rectangular in another, as in felspar and selenite. In calcareous-spar, the fragments are specular on every side; but in felspar, owing to the imperfect third cleavage, only on four sides.

C. *Trapezoidal.* Occur in foliated coal.

D. *Tetrahedral* or *three-sided pyramidal* and *octahedral*, occur in minerals having a fourfold cleavage, in which the folia meet under equal angles, as in fluor-spar. *Three and six sided prismatic fragments* occur in minerals having a fourfold cleavage, in which three of the cleavages are placed under equal angles around a common axis, and are rectangularly intersected by the fourth, as in beryl.

E. *Dodecahedral.* Fragments of this form occur in minerals having a sixfold cleavage. Sometimes three of the cleavages are disposed around an axis, and are obliquely intersected with other three, as in blende; in other instances all the six cleavages intersect each other under equal hexagon angles, and terminate in an apex, forming *double six-sided pyramidal fragments*, as in rock crystal.

2. *Irregular fragments.*

These have no regular form. They occur in minerals with a single cleavage, and in all the varieties of compact fracture. The following are the different varieties.

A.

A. *Cuneiform*, in which the breadth and thickness are much less than the length, and gradually and regularly diminish in magnitude from one end to the other. It occurs in minerals possessing a scopiform radiated fracture, as Cornish tin ore, red hematite, and radiated zeolite.

B. *Splintery*, in which the breadth and thickness are less considerable than the length, but without diminution of magnitude from one extremity to the other. It occurs in minerals having parallel fibrous, and radiated fractures, as in asbestus and bituminous wood.

C. *Tabular*, in which the breadth and length are more considerable than the thickness, and the middle is frequently thicker than the sides, which indeed are sometimes thin and sharp. It occurs in minerals with a single cleavage, as mica, also in slaty minerals, as clay-slate, and there is occasionally a tendency to it in minerals with a conchoidal fracture, as flint.

D. *Indeterminate angular*, in which the length, breadth, and thickness are in general nearly alike, but the edges differ much in regard to sharpness, which gives rise to the following distinctions.

a. Very sharp-edged, as in obsidian and rock crystal.

b. Sharp-edged, as in common quartz, pitchstone and jasper.

c. Rather sharp-edged, as in basalt and limestone.

d. Rather blunt-edged, as in pumice and copper-pyrites.

e.

e. Blunt-edged, as in gypsum and steatite.
f. Very blunt-edged, as in fullers-earth and loam.

VII. *The Aspect of the distinct Concretions.*

Distinct concretions are those portions into which certain minerals are naturally divided, and which can be separated from one another without breaking through the solid or fresh part of the mineral. They are separated from one another by natural seams, and frequently lie in different directions. When they are very much grown together, the natural seams are scarcely visible; in such cases, however, they can be distinguished by their different positions and resplendent lustre. They have been confounded with crystals and fragments, from both of which, as is evident from the preceding definition, they are completely different.

Here we have to consider, 1. The *shape of the distinct concretions*. 2. The *surface of the distinct concretions*; and, 3. The *lustre of the distinct concretions*.

VIII. *The Shape of the distinct Concretions.*

Distinct concretions, in regard to shape, are distinguished into *granular*, *lamellar*, and *columnar*.

1. *Granular distinct Concretions.*

When the concretions are tessular, or have their length, breadth, and thickness nearly alike, they are said to be granular. It is the most frequent form of the distinct concretion. They are distinguished according to *shape* and *magnitude*.

A. In regard to *shape*, they are

a. Round granular, which is either

α. Spherical, as in pea-stone and roe-stone.

β. Lenticular, as in red granular clay ironstone.

γ.

γ. *Date-shaped*, which is of a longish round shape, as in the quartz near Cullen in Banffshire, and of Prieborn in Silesia.

b. Angulo-granular, which is either

α. *Common angulo granular*, as in galena or lead-glance, and is very frequent.

β. *Longish angulo-granular*, as in red hematite and zeolite.

B. In regard to *magnitude*, into

a. Large granular, in which the size exceeds that of a hazel-nut, as in galena or leadglance, blende, and zeolite.

b. Coarse granular, in which the size varies from the size of a hazel nut to that of a pea, as in galena or leadglance, blende, mica, and peastone.

c. Small granular, in which the size varies from that of a pea to that of a millet-seed, as in galena or lead-glance, pea-stone, roe-stone, and black blende.

2. *Lamellar distinct Concretions.*

In the lamellar distinct concretions, the length and breadth are nearly alike, and more considerable than the thickness. They occur frequently, but not so often as the granular concretions.

They are distinguished in regard to *direction* and *thickness*.

A. In regard to *direction*, they are

a. Straight lamellar, which is either

α. *Quite straight*, as in straight lamellar heavy-spar, or

β. *Fortification-wise bent*, as in amethyst.

b.

b. Curved lamellar, which is either

α. Indeterminate curved lamellar, when it is not curved in any particular direction, as in specular iron-ore, or iron-glance.

β. Reniform curved lamellar, as in red and brown hematite, and native arsenic.

γ. Concentrical curved lamellar, when they are disposed around a central point. It is divided into *spherical*, as in calcedony and basalt, and *conical*, as in calc-sinter and brown hematite.

B. In regard to *thickness*, into

a. Very thick lamellar, when the concretions are upwards of half-an-inch thick, as in amethyst, and galena or leadglance.

b. Thick lamellar, when the thickness varies from half-an-inch to a quarter of an inch.

c. Thin lamellar, when the thickness varies from a quarter of an inch to a line, as in straight lamellar heavy-spar and calcedony.

d. Very thin lamellar, from that of a line, or the one twelfth of a line, to the smallest thickness visible to the naked eye, as in straight lamellar heavy-spar, native arsenic, and specular iron-ore or iron glance.

3. *Columnar or Prismatic distinct Concretions.*

In the columnar concretions, the breadth and thickness are inconsiderable in comparison of the length. They are the rarest of the distinct concretions.

They are distinguished in regard to *direction*, *thickness*, *shape*, and *position*.

A. In regard to *direction*, they are

a.

a. *Straight columnar*, as in schorl, and calcareous spar.

b. *Curved columnar*, as in columnar clay ironstone.

B. In regard to *thickness*, they are

a. *Very thick columnar*, when the thickness exceeds half an inch, as in amethyst and prase.

b. *Thick columnar*, from half-an-inch to a quarter of an inch, as in quartz and calcareous spar.

c. *Thin columnar*, from half an inch to the twelfth of an inch, as in columnar clay ironstone and schorl.

d. *Very thin columnar*, when it does not exceed the twelfth of a line, as in schorl. When the concretions become very minute, a transition is formed into the fibrous fracture.

C. In regard to *shape*, they are

a. *Perfect columnar*, when the length is considerable, and the thickness uniform from one end to the other, as in calcareous-spar and schorl.

b. *Imperfect columnar*, when the concretions are in general short, and sometimes thick in the middle, sometimes at the extremities, as in amethyst and specular iron-ore, or iron-glance. It passes into granular.

c. *Cuneiform columnar*, when the concretions become gradually narrower towards one extremity, as in calcareous-spar and quartz.

d.

d. Ray-shaped columnar, when the columnar concretions are compressed, as in specular iron-ore or iron-glance. It passes into radiated.

D. According to the *position*, they are

a. Parallel, as in amethyst.

b. Diverging, as in schorl.

c. Promiscuous, as in calcareous-spar and arsenical-pyrites.

It may be remarked, that when the concretions occur very much on the great scale, as is the case in rocks of the trap formation, a slight alteration of terms is used. Thus, in place of *granular* we say *massive*, and substitute *tabular* for *lamellar*, and always use *columnar*, never *prismatic*.

In several minerals, two varieties of distinct concretions, or different sizes of the same variety, occur together, either the one including the other, or the one traversing the other. Thus some varieties of schorl are composed of large granular concretions, and these, again, are formed of prismatic concretions; some varieties of straight lamellar heavy-spar, are composed of large granular concretions, and these, again, of thin and straight lamellar concretions; and peastone affords another example of the same kind of structure, it being composed of round granular concretions, and each of these of concentric curved lamellar concretions.

In other minerals we observe different kinds of distinct concretions intersecting each other, as in amethyst, where curved lamellar concretions intersect prismatic concretions, and in red and brown hematite, where granular

r concretions are intersected by lamellar concre-
ı.

VIII. *The Surface of the distinct Concretions.*

istinct concretions exhibit the following varieties of
ıce.

nooth, as in hematite and heavy spar; *rough*, as in
iron-stone; *streaked*, which is either *longitudinally*
ıked, as in schorl, *obliquely* streaked as in calcareous-
, or *transversely* streaked as in amethyst; *uneven* as
rown blende.

IX. *The Lustre of the distinct Concretions.*

is determined in the same manner as the external
:e.

IV. The General Aspect.

nder this head we include those characters for the
t which are observed in minerals in general. These
the *Transparency*, the *Streak*, and the *Soiling*.

X. *The Transparency.*

his character presents the five following degrees:

l. When a mineral, either in thick or thin pieces, allows the rays of light to pass through it so completely, that we can clearly distinguish objects placed behind it, it is said to be transparent. It is either *simply transparent*, that is, when the body seen through it appears single, as in mica and

 selenite;

selenite; or *duplicating*, when the body seen through it appears double, as in calcareous-spar.

The distance of the two images is in proportion to the thickness of the specimens, and is very inconsiderable in thin pieces. The duplicating property, or double refracting power of calcareous-spar, is observed by looking through two parallel planes; but in some other minerals it is observed by looking through two planes obliquely inclined on each other.

2. *Semi-transparent*; when objects can be discerned only through a thin piece, and then always appear as if seen through a cloud. It is the least frequent variety of this character, and occurs most frequently in siliceous minerals. Examples, Calcedony, common and precious opal, and carnelian.

3. *Translucent*. When the rays of light penetrate into the mineral and illuminate it, but objects cannot be observed either through thick or thin pieces, it is said to be translucent. Examples, Pitchstone, quartz, granular limestone, and massive fluor-spar.

4. *Translucent on the edges*. When light shines through the thinnest edges and corners, or when the edges are illuminated in the same degree as the whole mineral in the immediately preceding variety of transparency, it is said to be translucent on the edges. Examples, Hornstone, heliotrope, and compact limestone.

5. *Opaque*. When even on the thinnest edges of a mineral no light shines through, it is said to be opaque, as in chalk and coal.

The

The Opalescence.

ne minerals, when held in particular directions, re-
rom single spots in their interior a coloured shining
, and this is what is understood by opalescence. It
tinguished into

. *Common* or *Simple Opalescence*, when the lustre appears massive, in undivided rays, as in cat's-eye, and chrysoberyl.

. *Stellular Opalescence*, when the lustre appears in six rays, or in the form of a star, as in the variety of sapphire named from that circumstance *star-sapphire*. This phenomenon occurs principally in translucent minerals.

XI. *The Streak.*

the streak, we understand the appearance which
als exhibit when scratched or rubbed with a hard
as a knife or steel. In some instances the colour
: mineral is changed; in others the lustre, and fre-
ly neither colour nor lustre are altered.

e *streak*,

a. In regard to colour, is either

α. Similar to that of the mineral, as in chalk and magnetic cross ironstone; or

β. Dissimilar, as in specular iron-ore or iron-glance, which has a steel-grey colour, but affords a cherry-red streak; wolfram, which has a greyish-black colour, but a brownish-red streak; and red orpiment, which has an aurora red colour, but affords an orange-yellow streak.

b.

b. In regard to lustre, it remains

α. *Unchanged*, as in chalk.

β. *Is increased in intensity*, or *a shining or glistening lustre appears in minerals that otherwise have none.* Thus steatite, which is sometimes glimmering, becomes shining in the streak; and potters clay, fullers earth, and black-brown cobalt-ochre, which have no lustre, become glistening or shining in the streak.

c. Is diminished in intensity, or *altogether destroyed.* Thus, grey antimony-ore loses its lustre in the streak.

XII. *The Soiling or Colouring.*

When a mineral taken between the fingers, or drawn across another body, leaves some particles, or a trace, it is said to *soil* or *colour*.

It is a character which occurs but in few minerals, and only in those which are soft and very soft. Minerals are said to

1. *Soil*, either
   A. *Strongly*, as chalk, drawing-slate, and reddle.
   B. *Slightly*, as graphite, or
2. *Do not soil*, as molybdena.
3. *Write*, as chalk, graphite, reddle, molybdena, and black chalk or drawing-slate.

Having now explained the External Characters which are observable by the sight, we proceed to examine those which are made known to us by the senses of touch and hearing.

V.

V. Characters for the Touch.

[ere we have to observe, the Hardness, the Tenacity, Frangibility, the Flexibility, and the Adhesion to tongue.

XIII. *The Hardness.*

'he degrees are

1. *Hard.* When a mineral either does not yield to the knife, or is very slightly affected by it, but affords sparks with steel, it is said to be hard. It is further distinguished according as it is more or less affected by the file.
   A. *Resisting the file,* or *hard in the highest degree,* when it does not yield to the file, but rather acts on it, as diamond, sapphire, and emery.
   B. *Yielding slightly to the file,* or *hard in a high degree,* as in garnet, flint, quartz and calcedony, and very slightly to the knife.
   C. *Yielding readily to the file, but with great difficulty to the knife,* or *hard,* as porcelain jasper, iron-pyrites, and felspar.
2. *Semihard.* When a mineral gives no sparks with steel, and yields more readily to the knife than the preceding, it is said to be semihard, as fluor-spar, and grey copper-ore.
3. *Soft.* When a mineral is easily cut by the knife, but does not yield to the nail of the finger, it is said to be soft, as calcareous-spar, heavy-spar, serpentine, and galena or leadglance.
4. *Very soft.* A mineral is said to be very soft when it yields easily to the knife, and also

to

to the nail of the finger, as gypsum, steatite and chalk.

In our description of minerals, it is useful to mention their relative hardness, which is ascertained by trying which will scratch the other, by drawing the sharp edge or angle of one on the flat surface of the other. It is, however, of consequence to know, that in crystallised minerals, the solid angles and edges of the primitive forms are very sensibly harder than the angles and edges of the derivative forms, or than the angles and edges produced by fracture, either of crystals or of massive varieties of the same species. This fact has been long known to diamond cutters, who always carefully distinguish between the *hard* and *soft* points of this gem, that is, between the solid angles belonging to the primitive octahedron, and those belonging to any of the modifications; the latter being easily worn down by cutting and rubbing them with the former *. HAUY, in determining the relative hardness, uses plates of calcareous spar, glass, and quartz.

Observations. In examining the hardness of minerals, we must be careful to attend to the following circumstances:

1. Not to confound the real hardness of the mineral with accidental hardness, which latter is caused by the mixture of hard parts in soft minerals, and soft parts in hard minerals.

2.

* Vid. BRÜCKMANN's Abhandlung von Edelsteinen, 4ter. Aufl. s. 28, & 29. MOHS uber HAUY's Meionite, in VON MOLL's Efermeriden der Berg und Hüttenkunde 2ter Bandes, 1ste Lief, s. 3. AIKIN's Manual, p. 5.

When minerals are composed of distinct concretions, which are not very closely joined together, we must not give the hardness of the aggregate for that of the mineral, because the hardness in such cases must be taken from that of the individual concretions.

And we must be careful that the mineral whose hardness we wish to ascertain, is not in a state of decomposition.

XIV. *The Tenacity.*

tenacity is understood the relative mobility or the ent degrees of cohesion of the particles of minerals. e is a series from the coherent and completely im- able, to the coherent and moderately moveable, ı latter is expressed by malleability, and is the est degree of the mobility of the particles observed g solid minerals. This series continues through ent kinds of fluid minerals, and the greatest degree e mobility of the particles, is found in rock-oil. The es of tenacity are,

. *Brittle.* A mineral is said to be brittle, when on cutting it with a knife, it emits a grating noise, and the particles fly away in the form of dust, and leave a rough surface, which has in general less lustre than the fracture. In this degree of tenacity, the particles are completely immoveable. All hard, and the greater number of semihard minerals are brittle. Examples, Quartz, heavy-spar, and grey copper-ore.

. *Sectile* or *mild.* On cutting minerals possessing this degree of tenacity, the particles lose their connection in a considerable degree, but this takes place

glace without noise. The particles are closer than in the brittle variety, and do not fly off, but remain on the knife. The lustre is increased on the streak. This degree of tenacity occurs in most of the soft, and very soft minerals; and the only semihard mineral with this character is native arsenic. Examples, Galena or lead-glance, copper-glance, graphite, and molybdena.

3. *Ductile.* Minerals possessing this degree of tenacity can be cut into slices with a knife, and extended under the hammer. The particles are more or less moveable among themselves, without losing their connection. Examples, Native gold, native silver, and native iron.

XV. *The Frangibility.*

By frangibility is understood the resistance which minerals oppose when we attempt to break them into pieces or fragments with a hammer. It must not be confounded with hardness. Quartz is hard, and hornblende soft, yet the latter is much more difficultly frangible than the former. The degrees of frangibility are the following. 1. *Very difficultly frangible*, as in native malleable metals, in silver-glance or vitreous silver-ore, fine granular hornblende, and basalt. 2. *Difficultly frangible*, as hornstone and quartz. 3. *Not particularly difficultly frangible* or *rather easily frangible*, as flint, calcedony and copper-pyrites. 4. *Easily frangible*, as opal, calcareous-spar, and fluor-spar. 5. *Very easily frangible*, as

:raight lamellar heavy spar, galena or lead-glance, ılate coal *.

XVI. *The Flexibility.*

his term expresses the property possessed by some 'rals of bending without breaking. Flexible mine- ıre either *elastical flexible*, that is, if when bent they g back again into their former direction, as mica; *mmon flexible*, when they can be bent in different di- ɔns without breaking, and remain in the direction in h they have been bent, as molybdena, gypsum, talc, tus, and all malleable minerals.

XVII. *The Adhesion to the Tongue.*

ıis character occurs only in such minerals as possess roperty of absorbing moisture, which causes them to 'e to the tongue. It occurs principally in soft and soft minerals; it is not known in hard minerals, and is but one instance of its occurrence in semihard rals, that is, in the variety of semiopal called *oculus* i. The degrees of adhesion are, *strongly adhesive*,

 as

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ome earthy minerals, such as beryl, flint and opal, when first extract- ı their native repositories, are more difficultly frangible than after .ve been exposed for some time to the influence of the atmosphere, o their containing in these situations a considerable portion of water, ɔeing a nearly incompressible fluid, renders the mineral more diffi- rangible than it is after exposure to the atmosphere, when the water ıped, and the pores it occupied become filled with air, which is a ɔompressible substance.—Vid. AIKIN, p. 9.

as meerschaum, and oculus mundi; *pretty strongly* adhesive, as bole, and potters's-clay; *feebly adhesive*, as porcelain-earth, chalk, and tripoli; and *not at all adhesive*, as quartz and steatite.

VI. CHARACTERS FOR THE HEARING.

XVIII. *The Sound.*

The different kinds of sound occurring in the mineral kingdom are the following: 1. *A ringing sound*, which is a clear sound, as that of native arsenic, selenite and rock-crystal. Specimens to possess this property in full perfection, should have one or two dimensions, as length and breadth, greater than the thickness: 2. *A grating sound*, which is a very weak rough sound, resembling that emitted by dry wood or fresh burnt clay when rubbed, and is produced when the finger is drawn across certain minerals, as mountain-cork and mealy zeolite: 3. *A creaking sound*, which is a harsh sharp sound, as that of natural amalgam, when pressed by the hand.

Having finished the explanation of the characters that are presented by Solid Minerals, we shall now give an account of those which occur in Friable and Fluid Minerals. These are very few in number, because few fluid or friable minerals occur in nature.

PARTI-

II.

TICULAR GENERIC EXTERNAL CHARACTERS OF *FRIABLE* MINERALS.

he external characters of Friable Minerals form a icular Section in the System, because they exhibit ties and kinds that do not occur in solid minerals, and y of the characters of solid minerals, such as frac-, distinct concretions, streak, hardness, and frangibi- and others, are wanting.

I. *The External Shape.*

ı Friable Minerals there are but few external shapes. five following kinds are all that have been hitherto ribed by naturalists.

1. *Massive*, as in porcelain-earth, and scaly red and brown iron-ores.
2. *Disseminated*, as in earthy azure copper-ore, and blue iron-earth.
3. *Thinly coating* or *incrusting*. It is analogous to the form in membranes. Examples, Copper-black, or black oxide of copper.

4. *Spumous.*

4. *Spumous.* When a friable mineral appears like froth resting on a solid mineral, as is sometimes the case with scaly brown iron-ore.

5. *Dendritic*, also in scaly brown iron-ore.

II. *The Lustre.*

It is determined in the same manner as in solid minerals; we have here, however, the following distinctions.

1. In regard to *Intensity.*

   A. *Glimmering*, which is either strong or feeble, as in scaly brown ironstone, and porcelain-earth.

   B. *Dull*, as in black cobalt ochre.

2. In regard to the *Sort* of Lustre.

   A. *Common glimmering*, as in scaly and brown iron ores.

   B. *Metallic glimmering*, as in scaly red and brown iron ores, and *Pearly glimmering*, as in earthy talc.

III. *The Aspect of the Particles.*

The particles of friable minerals appear in some instances like dust, so that we can with difficulty distinguish by the naked eye any dimensions; these are called *dusty particles*, and occur in cobalt-crust, blue iron-earth and porcelain-earth; in others two dimensions can be observed, when they appear foliated, and these are called *scaly particles*, and occur in scaly brown and red iron-ores, earthy talc and chlorite-earth.

IV. *The*

IV. *The Colouring or Soiling.*

nerals colour either *strongly*, as in scaly red and ı iron ores, and porcelain-earth; or *slightly*, as in cobalt-ochre.

V. *The Adhesion to the Tongue.*

is character occurs only in those friable minerals ı are cohering. It varies in intensity, being either : or strong.

VI. *The Friability.*

able minerals are either *loose*, that is, when the les have no perceptible coherence, as in blue iron- ; or *cohering*, in which the particles are slightly cted together: they are either *feebly cohering*, as in lain-earth, or *strongly cohering*, as in potters-

PARTI-

III.

PARTICULAR GENERIC EXTERNAL CHARACTERS OF *FLUID* MINERALS.

Fluid minerals possess fewer characters than friable minerals. The following four are all that occur.

1. *The lustre* is either *metallic*, as in mercury; or *resinous*, as in rock oil. The lustre is always splendent.
2. *The transparency*. The following are all the degrees necessary for the purposes of discrimination. 1. *Transparent*, as in naphtha. 2. *Troubled* or *turbid*, as in mineral oil: and, 3. *Opaque*, as in mercury.
3. *The fluidity*. Here we have only two degrees to observe, 1. *Fluid*, as in mercury and naphtha; 2. *Viscid*, as is sometimes the case with mineral-oil.
4. *The wetting*, by which we understand the wetting of the fingers when they touch the mineral. It is analogous to the soiling in solid and friable minerals. Mineral oil wets the finger, but mercury does not.

RE-

MAINING GENERAL GENERIC EXTERNAL CHARACTERS.

III. THE UNCTUOSITY.

ne minerals feel *greasy*, others *meagre*, and in order tinguish the different degrees of greasiness, the fol- g distinctions are employed.

Very greasy, as talc and graphite.

Greasy, as steatite and fullers earth.

Rather greasy, as asbestus and polished serpentine.

Meagre, as cobalt.

ie greasy and very greasy minerals are generally ve- ft and sectile, and become shining in the streak. feels smooth, but not greasy; porcelain earth feels nd fine, but not greasy.

IV. THE COLDNESS.

hen different kinds of minerals, all having equally th surfaces, are exposed for some time to the same erature, we find by feeling them that they possess ent degrees of cold. To use this character with sion much practice is required; but those who have itomed themselves to it, are able, by the mere feel, to iguish serpentine, gypsum, porphyry, alabaster, :, &c. from one another, and can also distinguish ar- tificial

tificial from true gems. It is, however, principally used in determining polished specimens. The different degrees mentioned in the Tabular View are,

1. *Very cold.* Examples, the precious stones, mercury, and agate.
2. *Cold.* Examples, Polished marble or limestone.
3. *Pretty cold.* Examples, Serpentine, and gypsum or alabaster.
4. *Rather cold.* Examples, Coal and amber.

V. THE WEIGHT.

The degrees of the specific gravity of minerals are the following.

1. *Swimming*, or *supernatant*, which comprehends all minerals that swim on water, and in which the specific gravity is under 1000, water = 1000. Example, Mineral oil, mountain cork, and mineral agaric.
2. *Light*, in which the specific gravity varies from 1000 to 2000. Examples, Amber, sulphur, and black coal.
3. *Not particularly heavy*, or *rather heavy*, in which the specific gravity varies from 2000 to 4000. Examples, Quartz, flint, and calcedony.
4. *Heavy*, from 4000 to 6000. Examples, Heavy spar, copper-pyrites, and iron-pyrites.
5. *Uncommonly heavy*, all minerals having a specific gravity above 6000. Examples, Native metals, as gold, silver, &c.; ores, as galena or leadglance, tinstone, &c.

The first and second degrees, which comprehend the swimming and light minerals, contain all the inflammable minerals;

nerals; the third, with a few exceptions, all the earthy nerals; the fourth, the greater number of the ores; l the fifth, the native metals and a few ores.

VI. THE SMELL.

Of this we can give no definition, and shall therefore il-trate it by the minerals in which it occurs.

It is observed either when

1. *Spontaneously emitted*, in which case it is
   - *a. Bituminous*, as mineral oil, and mineral pitch.
   - *b. Faintly sulphureous*, as natural sulphur.
   - *c. Faintly bitter*, as radiated grey antimony-ore.
2. *After breathing on it*, in which a *clayey like smell*, as in hornblende and chlorite, is produced.
3. *Excited by friction.*
   - *a. Urinous*, in stinkstone.
   - *b. Sulphureous*, in iron-pyrites.
   - *c. Garlick-like*, or *arsenical*, in native arsenic and arsenic pyrites.
   - *d. Empyreumatic*, in quartz and rock crystal.

VII. THE TASTE.

This character occurs principally in the saline class, for ich it is highly characteristic.

The varieties of it are

1. *Sweetish taste*, common salt.
2. *Sweetish astringent*, natural alum and rock-butter.
3. *Styptic*, blue and green vitriol.
4. *Saltly bitter*, natural Epsom salt.
5. *Saltly cooling*, nitre.
6. *Alkaline*, natural soda.
7. *Urinous*, natural sal-ammoniac

On Describing Minerals.

Most of the species exhibit many varieties of character which are generally distributed throughout a number of individual specimens; hence it follows, that in order to obtain a distinct conception of a species, we must examine not one, but many different specimens of it. The descriptions of the species ought to be executed in the order laid down and followed in the preceding account of the External Characters; that is, beginning with colour, and then the other characters, in the order there stated.

The following description may serve as an example of the mode of arranging the External Characters.

Precious Garnet.

External Characters.

All the colours of this mineral are *deep-red*, which always inclines to blue; the principal colour is *columbine-red*, which passes into *cherry-red*, and *blood-red*, and it appears even to run into *brownish-red* and *hyacinth-red*.

It rarely occurs massive, sometimes *disseminated*, and in *angular pieces*; but most frequently in *roundish grains*; and *crystallised*, in the following figures:

1. The *rhomboidal dodecahedron*, which is the fundamental figure.
2. The rhomboidal dodecahedron, *more or less deeply truncated on all the edges*. When the truncating planes become so large as to obliterate the original planes, there is formed the
3. *Leucite crystallisation*.

4.

4. *Rectangular four-sided prism*, acuminated on both extremities with four planes which are set on the lateral edges.

The fundamental crystallisation alternates from *very rge* to *very small*; the others are *middle-sized*, *small*, and *ry small*.

The crystals are *all around crystallised*, and *imbedd*.

The *surface* of the grains is usually *rough*, *uneven*, *granulated*; that of the crystals is almost always *ooth*.

Internally it alternates from *splendent* nearly to glistiing, and the lustre is intermediate between *vitreous* and *sinous*.

The fracture is *more or less perfect conchoidal*; and metimes *concealed foliated*.

The fragments are indeterminate angular, and rather arp-edged.

It sometimes occurs in *lamellar distinct concretions*.

It alternates from *transparent* to *translucent*.

It is so hard as to scratch quartz.

It is rather difficultly frangible.

It is *heavy*.

Specific gravity 4.230, *Werner*.

Werner recommends the more essential characters of e mineral to be printed in a different letter from that of e others, in order that they may more readily strike the re,—a practice which is followed in the preceding deription.

MINERAL

Mineral Collections.

In arranging collections of simple minerals, the same method ought to be followed as in the descriptions of them; that is, all the varieties of each character ought to be brought together and arranged in a natural order; and each series should follow in the order of the description. Thus all the different kinds of colour should be arranged together, and placed first; next the different varieties of form; then of lustre; fracture; fragments; distinct concretions; transparency; streak, &c. A complete collection, arranged in this way, forms a most interesting and beautiful spectacle, and it also enables us readily to acquire a perfect and distinct conception of the species, however extensive it may be.

The possession of a well arranged Collection of Minerals assists very much in the knowledge and discrimination of mineral species. In the progress of our mineralogical studies, we should omit no opportunity of visiting and examining mineralogical cabinets, the collections of jewellers, the work shops of lapidaries, and in our walks and journies, every mineral that comes in our way ought to be examined and referred to its place in the system. In this island, there are already many valuable mineralogical cabinets, both public and private, the access to which is liberally granted to all those who take an interest in mineralogy.

In Scotland, the most considerable public collections are those of the University of Edinburgh, and of the Professor of Natural History, which are exhibited and explained

ined during the Lectures on Mineralogy. In the erian Museum at Glasgow there are many valuable interesting specimens of minerals. The most com- private cabinets in Scotland are those of ROBERT USON, Esq. of Raith, and of THOMAS ALLAN, Esq. burgh.

e Mineralogical Collection in the British Museum, the addition of the GREVILLE Cabinet, is now so sive and complete, that it is considered as one of ost valuable in Europe. The collections of Sir HAM HUME, and of Mr HEWLAND, are also very sting, and particularly rich in the rarer and more ble minerals. The Leskean Cabinet in Dublin, roperty of the Dublin Society, originally of consi- le extent, is daily increasing, and very lately has re- l valuable additions by the contributions of their nt Professor of Mineralogy, M. GIESEKE *.

CHEMICAL

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t is to be regretted, that there are no regular Collections of Minerals d in Edinburgh, the lapidaries confining their attention principally utting and polishing of gems, agates, &c. In London, however, the has an opportunity of purchasing small collections, which will aid y much in his studies. Mr MAWE, 149 Strand, London, has advertised ions of this description. On the Continent, many mineral dealers small assortments for the use of the student; the best chosen ranged collections of this description are those made by the Inspector AN at Freyberg, and by Dr LEONHARD at Frankfort on the Maine. xtensive and costly collections are sold by Mr HEWLAND of Lon- d also by Mr MAWE.

CHEMICAL CHARACTERS

OF

MINERALS.

1. *Action of the Atmosphere.*

2. *Action of Water.*

3. *Action of Acids.*

4. *Action of the Blowpipe.*

CHEMICAL CHARACTERS

OF

MINERALS.

ıE Chemical Characters of Minerals are those we ob-
by their Complete Analysis; and the changes induced
hem by the action of the Atmosphere,—Water,—
ls,—and Heat, by means of the blowpipe. In this
rk, we shall not enter on the various modes followed
hemists in the Complete Analysis of minerals, but
ine ourselves to a short account of the Chemical
racters obtained by the other means just enumera-

1. *Action of the Atmosphere.*

[any minerals, on exposure to the atmosphere, expe-
:e considerable changes in colour, lustre, hardness, or
y, fall in pieces, deliquesce, are converted into vi-
, &c. owing partly to the abstraction of the water,
:h enters as a constituent part into many minerals,
ly to the absorption of water from the atmosphere

 by

by the minerals, or to the oxidation of some of the constituent parts of the mineral.

2. *Action of Water.*

Water either forms a chemical combination with minerals, and completely dissolves them, as is the case with the mineral salts; or it acts by simply destroying their state of aggregation, when the mineral falls into small pieces with an audible noise, as is observed in bole: or it falls without noise, into small pieces, which are soon diffused through the fluid, without either dissolving in it, or becoming plastic, as in fullers'-earth, and some minerals, as unctuous clays, it renders plastic. Other minerals absorb water in greater or less quantity, which alters their transparency, and also their colour.

3. *The Action of Acids.*

Acids act powerfully on many different minerals, and are the principal agents employed in their complete analysis. When we wish, by means of acids, to obtain some obvious characters, the dilute muriatic acid is that which is generally employed. The native carbonates effervesce, and are soluble in it. In some, as in agaric mineral, calcareous-spar, and witherite, the effervescence is brisk, and the solution rapid; in others, as in dolomite, even when pulverized, the effervescence is feeble, and the solution slow. Some of the earthy minerals which contain silica, water and alkali, in a particular state of combination, if pulverized, and covered with an acid, are, in the space of a few hours, converted into a perfect jelly, as zeolite.

4. *The*

4. *The Action of the Blowpipe.*

The blowpipe is a tube of silver, copper, brass, or of glass, for delivering a continued stream of air. The stream being directed across a flame, turns it more or less from its vertical position, concentrating it at the same time, and occasioning a more powerful combustion. The air employed is generally either that of the atmosphere, or air which has been breathed; sometimes oxygen gas is made use of, and sometimes an inflammable gas, as the vapour of boiling alcohol. The continued stream of air is furnished by some apparatus, such as a pair of double bellows, a gazometer, a large bladder, or, what is most convenient of all, by blowing with the mouth.

Few persons, Mr Aikin remarks, are able at first, to produce a continued stream of air through the blowpipe, and the attempt often occasions a good deal of fatigue. The first thing to be done is, to acquire the habit of breathing easily, and without fatigue, through the nostrils alone; then to do the same when the mouth is filled and the cheeks inflated with air, the tongue being at the same time slightly raised to the roof of the mouth, in order to obstruct the communication between the mouth and the throat. When this has been acquired, the blowpipe may be put into the mouth, and the confined air expelled through the pipe by means of the muscles of the cheeks; as soon as the air is nearly exhausted, the expiration from the lungs, instead of being made through the nostrils, is to be forced into the cavity of the mouth; the communication is then instantly to be shut again by the tongue, and the remainder of the expiration is to be expired through the nostrils. The

second,

second, and all subsequent supplies of air to the blowpipe are to be introduced in the same manner as the first: Thus, with a little practice, the power may be obtained of keeping up a continued blast for a quarter of an hour, or longer, without inconvenience. Much depends on the size of the external aperture of the blowpipe. If so large that the mouth requires very frequent replenishing, the flame will be wavering, and the operator will soon be out of breath; if, on the other hand, the aperture be too small, the muscles of the cheeks must be strongly contracted, in order to produce a sufficient current, and pain and great fatigue of the part will soon be the consequence. An aperture, about the size of the smallest pin-hole, will generally be found the most convenient, though, for particular purposes, one somewhat larger, or a little smaller, may be required.

The fuel for the lamp is oil, tallow, or wax; and of these the wax is the best, the oil the worst. The wick should neither be snuffed too high nor too low, and should be a little bent at its summit *from* the blast of the pipe. The flame, while acted on by the blowpipe, will consist of two parts, an outer and inner: the latter will be of a pale blue colour, converging to a point at the distance of about an inch from the nozzle; the former will be of a yellowish colour, and will converge less perfectly. The most intense heat is just at the point of the blue flame. The white flame consists of matter in a state of full combustion, and oxygenates substances immersed in it: the blue flame consists of matter in a state of imperfect combustion, and therefore partly de-oxygenates metallic oxides which are placed in contact with it.

Various substances are employed for supporting the mineral, when undergoing the action of the blowpipe. These

These are of two kinds, combustible and incombustible. The combustible support, used chiefly for ores, is charcoal. The closest grained and soundest pieces of charcoal, of elder or lime-tree, are to be selected; or a support may be made of well pulverised and heated charcoal and gum tragacanth. The gum should be dissolved in water, and powder of charcoal added to it, until it becomes very viscid, when it is to be formed into parallelopipeds, and slowly dried. The incombustible supports are, metal, glass, and earth; in the use of all which, one general caution may be given, to make them as little bulky as possible. The best metallic support is platina, because it is infusible, and transmits heat to a less distance, and more slowly, than other metals. A pair of slender forceps of brass, pointed with platina, is the best support for non-metallic minerals, which are not very fusible; for the fusible earthy minerals, and for the infusible ones when fluxes are used, leaf-platina will be found the most convenient. It may be folded like paper into any form, and the result of the experiment may be obtained, simply by unfolding the leaf in which it was wrapped up. Glass supports, are slender glass tubes, on the extremity of which the mineral to be examined is cemented by heating. Earthen supports are, either of small pieces of kyanite, or, when a kind of cupellation is to be performed, they are made of bone-ash, in order to absorb the litharge, and other impurities.

The size of the specimens to be used in our experiments, depends in some measure on the magnitude of the flame to which they are exposed. In a blowpipe having an aperture not larger than a fine pin, the piece ought not to be so large as a pea. A good deal also depends on the fusibility of the mineral; for if it is very fusible, a much larger piece may

may be used than when it is difficultly fusible: in the one case, it may be the size of a pea; in the other, it should not exceed that of a pin's head. The heat first applied to investigate the properties of mineral substances should be very low, not exceeding that which exists a little the outside even of the yellow flame. At this temperature, the phosphorescence is best extricated, and decrepitation for the most part takes place, the fusible inflammables begin to melt, and the metallic and most other mineral salts lose their water of crystallisation. The yellow flame will raise a mineral to a tolerably full red heat; and it is the temperature best fitted for roasting all the metallic ores. In the still higher degree of heat produced at the point of the interior blue flame, although some minerals still continue refractory, and undergo but little change of any kind, yet the greater part are very sensibly altered. Some, as pearlstone, enlarge very considerably in bulk at the first impression of the heat, but are with difficulty afterwards brought to a state of fusion; others are melted only on the edges and angles; and in some, a complete fusion takes place.

In examining earthy minerals with the blowpipe, no fluxes are required; whereas to most of the metallic ores fluxes will be found at almost all times a very useful and often a necessary addition. The ores of the difficultly reducible metals, such as manganese, cobalt, chrome, and titanium, are characterised by the colours which their oxides give to glass. In all these cases, therefore, glassy fluxes must be largely made use of, both to dissolve the earthy matter with which the oxides are generally combined, and to furnish a body, with little or no colour of its own, which may receive, and sufficiently dilute, the inherent colour of the oxide. When the object is not

only

only to dissolve the oxide, but at the same time to retain it at a high state of oxidation, the flux employed should be either nitre, or a mixture of this with glass of borax, or, still better, nitrous borax, formed by dissolving common borax in hot water, neutralizing its excess of alkali by nitrous acid, then evaporating the whole to dryness, and lastly, hastily melting it in a platina crucible. For an active, and at the same time non-alkaline flux, boracic acid may be used, or neutral borate of soda; and where a slight excess of alkali is required, or at least does no harm, common borax by itself, or mixed with a little cream of tartar, when a strong reducing flux is required, may be had recourse to. For coloured glasses, the proper support is leaf-platina, but for reductions charcoal. In the latter case, the ore, previously roasted, if it contain either sulphur or arsenic, is to be pulverised, and accurately mixed with the flux; a drop of water being then added, to make it cohere, it is to be formed into a ball, and deposited in a shallow hole in the charcoal, being also covered with a piece of charcoal, if a high degree of heat is required. In the easily reducible metals, a bit of the ore being placed in the charcoal, and covered with glass of borax, will, in the space of a few seconds, be melted by the blowpipe, and converted into a metallic globule, imbedded in a vitreous scoria. In all cases where a metallic globule is obtained, it should be separated from the adhering scoria, and examined as to its malleability, and other external characters: being then placed a second time on the charcoal, but without flux, it is to be brought to the state of a gentle ebullition, during which, the surface being oxygenated, will exhale a heavy vapour, that condenses on the blowpipe, or falls down on the charcoal, in the form of a powder, or of

specular

specular crystals, from the colour, and other characters of which, the nature of the metal may probably be ascertained. If any suspicion is entertained of a portion of silver or of gold being mixed with the oxydable metal, the button must be placed on an earthen support, and there brought to a full melting heat: by degrees, the oxydable metal will become scorified, and will entirely sink into the support, leaving on the surface a bright bead of *fine metal*, if any such was contained in the alloy; but the proportion of this last being generally very small, and the entire mass of the alloy often not exceeding alarge shot, it is not unfrequently necessary to have recourse to the magnifying-glass to be fully convinced of the presence or absence of the fine metal *.

As it is of importance to know particularly the various changes induced on minerals by the action of the blowpipe, we shall now give a short enumeration of them †.

I.—*Changes which are effected on Minerals by the simple action of the Heat of the Blowpipe, without the Addition of Fluxes.*

i. Appearances which are not necessarily accompanied with any *permanent change* of the mineral.

a.

* The observations on the action of the blowpipe, I owe to Mr AIKIN.—Vid. Man. p. 35.

† Vid. HAUSMANN, in LEONHARD'S Taschenbuch.

a. *Phosphorescence.* There are two kinds of this phenomenon: in the one there is but a single colour, which is either white or red; in the other, there are many different colours, with a very bright light, as we observe in fluor-spar and apatite.

b. *The colour of the flame.* Thus, Celestine, or sulphate of strontian, colours the blue part of the flame of the lamp pale red.

Appearances which are associated with *permanent changes* of the mineral.

A. *Changes which do not affect the form of the mineral.*

1. *Alterations in the Colour,* in which are to be observed,

a. The *tarnish.*

α. *Simple tarnish.*

β. *Variegated tarnish.* Examples. Pyrites.

b. *Total alteration of colour,* in which the colour of the whole mass of the mineral is changed. Thus, Yellow iron-ochre becomes throughout red, red cobalt-ochre blue, and lucullite loses its colour.

2. *Destruction of the lustre,* of which there are examples in white mica, and foliated gypsum.

3. *Change, or complete destruction of the transparency.* White mica, when exposed to the flame of the blowpipe, affords an example of this character.

4. *Change of the refracting power.* Some transparent minerals, when exposed to the blowpipe, become cracked in the direction of the cleavages, and thus experience a change in

 their

their refracting power. This appearance affords us an excellent mean of ascertaining the cleavage of some minerals. Example, Heavy-spar.

5. *Changes in solidity.*

a. Increase of hardness, as in potters clay.

b. Calcination or diminution of hardness, as in calcareous-spar.

6. *Extrication of smell.*

The mineral named *pyrosmalite* exhales the smell of oxygenated muriatic acid.

7. *Acquiring a taste.*

Thus some, as calcareous-spar, acquire an *alkaline taste*; others, as heavy-spar, a *hepatic taste*; and some, as celestine, or sulphat of strontian, an *acid taste*.

B. *Changes which alter the Form, and slightly affect the Substance of the Mineral.*

1. *The loss of water of crystallisation*, as in borax, and alum.

2. *Decrepitation*, or the splitting of minerals into larger and smaller fragments, with more or less force, and with a louder or feebler noise; by which the water of crystallisation of the mineral is converted into vapour, or the air in its interstices is expanded. Two kinds of this character may be distinguished; in the one, as in galena or lead-glance, the mineral splits into larger pieces, with a loud noise; in the other, as in rock salt, it springs into smaller pieces, with a feebler noise.

3.

3. *Sublimation*, when a portion of the mineral is changed into vapour, without undergoing any other change, as is the case with mercury.
4. *Exfoliation*, or the separation of the folia of a mineral from each other, by which its bulk is increased. This is principally caused by the separation of the water of crystallisation. Examples, Foliated gypsum, spodumene, and radiated zeolite.
5. *Efflorescence*, when moss-like shoots appear on the planes or edges of the mineral. It occurs, although not in a very striking manner, in topaz. It is probably caused by the escape of a very minute portion of gas.
6. *Intumescence*, when the mineral increases in bulk, during which a number of small air bubbles are formed, thus giving to the mass a spumous aspect. This is caused either by the escape of air or vapour, or both. Examples, Meionite and lepidolite.
7. *Boiling*, when, in melting, a mineral exhibits a bubbling motion, or appears much agitated, as is the case in the fusion of borax, and basaltic hornblende.
8. *Arborisation*, when the whole mass shoots into a fruticose, branched, coralloidal, or contorted form, as in borax, fibrous zeolite, gadolinite, and prehnite.
9. *Rounding*, when the edges and angles are melted and lose thereby their sharpness, as is the case with talc and other minerals.

10.

10. *Glazing*, when only the surface of the mineral melts, and it appears as if covered with a glaze or varnish, as in grenatite.

11. *Fritting*, when single parts of the mass are melted, while others remain unaltered. This character is well seen in those varieties of compact felspar which are mixed with quartz. It often enables us to discover intermixtures in minerals which otherwise would escape our notice.

12. *Imperfect fusion*, when the whole mineral runs into an imperfect tenacious mass, and therefore does not form a globule, as in chlorite.

13. *Perfect fusion*, when the whole mineral is perfectly melted, and forms a globule or bead, as in felspar and borax.

14. *Crystallisation*, when a mineral, after it has been fused, and begins to cool, assumes a regular external form. Examples, Brown and green lead-ores, and carbonate of soda.

C. *Changes which alter the Form and Substance of the Mineral.*

1. The *burning* or *oxidation*, when a part, or the whole of the mineral unites with oxygen, during which the following appearances are to be distinguised.

   a. The *glowing*, during which there is a slow combustion, and volatilisation of the combustible, but without flame or smoke, as in glance-coal.

b.

b. The *flaming*. Rapid combustion with flame, in which we have to notice the different colours of the flame, as in black coal.

c. The *smoking*. Volatilisation of the mineral with smoke, which is again readily deposited on cold bodies. Examples, Black coal, and native antimony.

d. The *oxidation* or *calcination*, which is the conversion of a mineral into an earthy metallic oxide, either on the surface, or through the whole mass of the mineral.

e. The *vitrification*, or the conversion of the mineral into a glassy metallic oxide.

f. The *coaking*. The conversion of a mineral into a coak, as in black coal.

g. The *incineration*. The conversion of a mineral by combustion into ashes, which occurs in some instances only on the surface, as in glance-coal; in others, again, throughout the whole mass, as in brown coal, and some kinds of black coal.

2. The *reduction*, when the mineral is reduced to the metallic state, as white lead-ore by the escape of carbonic acid, tinstone by the abstraction of its oxygen, and cinnabar by the escape of its sulphur.

heating minerals without addition before the blow-
we have further to attend to the other conditions of
ccurring phenomena.

The *time* in which they precede each other, whether they follow,

a.

α. Very quickly.
β. Quickly.
γ. Slowly.
δ. Very slowly.

b. According as *one* or *several* occur.
α. When a mineral shews but one of the above-mentioned phenomena, as in the melting of compact felspar.
β. When many occur in succession, as in the bubbling, boiling, and melting of borax.
γ. When many occur at the same time, as in black coal, when smell, flame, smoke and coaking occur together.

c. The degree of alteration which a mineral experiences, is either
α. *Great*, when a greater portion of the mass is altered.
β. *Small*, when a small part of the mineral is changed.

d. *The universality of the change;* in which respect they are said to be
α. *Complete*, when it refers to all the constituent parts of the whole mineral, as in native antimony, which is entirely volatilised in the form of smoke.
β. *Partial*, when the change is only in part, not in all the constituents of the mineral. Thus, in antimonial silver-ore, the antimony is volatilised, but the silver remains; and in glance-coal the coaly parts disappears while the earthy parts remain behind in the form of ashes.

II.

Changes effected on Minerals when mixed with Fluxes, or reducing agents, and exposed to the Heat of the Blowpipe.

i. *Fluxes.*

arious kinds of fluxes are used in assisting the melting or fusion of the mineral; some of which, under certain circumstances, act as reducing agents, others, as nitre, as oxidising agents. They are first pounded, and those which have water of crystallisation are deprived of it by heating, and either ground fine with the mineral to be examined, and a portion of it, dry or moistened with water, is brought before the blowpipe; or the flux is first brought to a state of complete fusion, and the mineral, either in the state of powder, or in small pieces, is thrown into the liquid flux, and the blowing is continued.

a. The principal fluxes are the following:

1. *Red lead,* for many earthy minerals.
2. *Fluor-spar,* which is a good test for gypsum, with which it forms an enamel.
3. *Gypsum,* which is an excellent test for fluor-spar.
4. *Borax,* which is of very general application in earthy and metalliferous minerals, sometimes as a flux, sometimes as a reducing agent. It is used with most advantage when in the state of glass.

5.

5. *Borax-nitre*, or borax in which its excess of alkali is saturated with nitre. It is an excellent flux, particularly for metalliferous minerals.
6. *Carbonate of Soda*, an excellent test for siliceous minerals.
7. *Cabonate of potash.*
8. *Microcosmic salt.* A very generally useful flux.
9. *Glass of phosphorus*, which is phosphoric acid in the state of glass.
10. *Nitre*, a flux particularly fitted for inflammable minerals, and also a powerful flux for metallic minerals.

All the different kinds of flux, with exception of nitre and borax-nitre, which deflagrate with charcoal, may be used with any of the usual supports.

ii. *Reducing Agents.*

i. These either abstract oxygen from the mineral, or protect it from the action of that gas.

Charcoal, which is used as a support, acts in this way; but charcoal powder is much more efficacious. Oil is sometimes also employed as a reducing agent, when it is mixed with the mineral in a finely pounded state.

In treating minerals with fluxes and reducing agents, we have further to observe,

iii. *Their relation to the Fluxes.*

Here we have to attend to

a. The *solubility* or *insolubility* of minerals in the fluxes. During the solution we have to observe, whether it is effected *calmly*; with the *evolution of gas*, as in the solution of grey

grey manganese-ore in borax; or with a kind of *intumescence;* and we have also to notice whether it is effected *quickly* or *slowly.*

b. The colouring of the flux, in which is to be noticed,

α. The *kind of colour* which the melted mass assumes. Thus borax becomes smalt-blue when melted with cobalt-ochre; of a hyacinth-red colour, when melted with a small portion of grey manganese-ore; but of a violet-blue colour, when a greater portion of that ore is used; and black with other minerals.

β. *The degrees of fixity of the colours.* It is in this respect

1. *Fixed,* as in the blue colours which borax communicates to glass.
2. *Evanescent,* when the colour remains as long as the mineral is in a state of fusion, but disappears on cooling. Thus glass of borax, in which a ferruginous mineral has been dissolved, has a green colour when in a state of fusion, but which disappears on cooling.
3. *Changeable,* when the colour of a glass is changed according to the part of the flame in which it is held. Thus glass of borax, with a little oxide of manganese, is of a violet-blue colour when kept in the oxidising part of the flame; but loses this colour when exposed to the reducing part of the flame.

c. *The Reduction of the minerals in the fluxes, or reducing agents*, which is either

α. *Perfect*, when all the parts of the mineral are reduced.

β. *Imperfect*, when only part is reduced.

III.—*The various Products obtained by the action of the Blowpipe on Minerals.*

They may be divided into the following kinds:

A. *Glass*, which is a more or less transparent substance, with a smooth surface, conchoidal fracture, and vitreous lustre. It may be distinguished in regard to

1. *Density*, into
   - a. *Compact* glass.
   - b. *Vesicular* glass, with single vesicular cavities.
   - c. *Spumous* glass, with so many vesicular cavities as to give the mass a spumous character, as in obsidian and pitchstone.
2. *Transparency*, into
   - a. *Clear glass*, which is transparent.
   - b. *Clouded glass*, with transparent places, but partially clouded.
   - c. *Muddy glass*, which is only translucent.

B. *Enamel*, which is an opaque body, with smooth surface, conchoidal fracture, and a vitreous lustre, sometimes inclining to waxy. It is distinguished in regard to

1. *Density*, into
   - a. *Compact*, as in gypsum.
   - b. *Vesicular*, with single vesicles.

c.

c. *Spumous*, with many vesicles, as in fibrous zeolite.

2. *Colour*, which is

Snow-white, as in gypsum, fibrous zeolite and gypsum; *greenish-white*, as in nephrite.

C. *Slag*, which is generally an opaque, seldomer a translucent body, with the surface full of holes. In regard to

i. *Density*, it is

a. *Compact.*

b. *Vesicular.*

c. *Spumous.*

ii. *Lustre*, it is

a. *Dull.*

b. *Glassy.*

c. *Metallic.*

iii. *Colour*, it is

a. *Black.*

b. *Brown*, &c.

iv. In regard to the *magnet*, it is

a. *Attracted by the magnet*, as in the slag of chlorite, and several varieties of mica.

b. *Not attracted by the magnet.*

D. *Frit*, which is a body exhibiting on its fracture-surface parts vitrified and parts unvitrified. Here the colour also is to be attended to.

E. *Regulus* or *King*, which is a metallic globule.

F. *Ochre*, an earthy-like metallic oxide, in which the colour is to be attended to.

G.

G. *Coak*, is common black coal after the dissipation of its more volatile parts.

H. *Charcoal*, is a black, light, feebly glimmering, easily incinerated, *hydro-carbonated* body.

I. *Ashes*.

K. *Incrustation*, which is a fine dust-like powder, deposited during the volatilisation of a mineral on its support, or upon a cold body held over it. It may differ in kind:

1. *Soot*, a black or brown coaly substance, formed from black coal, &c.
2. *Sulphur*.
3. *Metallic oxides*, in which we have to attend to the
   a. *Kind of colour*, which is
      α. *White*, as in antimonial and arsenical incrustations.
      β. *Yellow*, as in incrustations of lead.
   b. *Degree of fixity of the colours*, which is
      α. *Fixed*, as in incrustations of antimony.
      β. *Changeable*, at different temperatures. Thus bismuth-crust or incrustation continues of a yellow colour, as long as the flame plays upon it; but becomes white on cooling.

IV.—*Changes that take place in the Products after the Experiments are finished.*

Thus heavy-spar may be melted so as to form an enamel; but this enamel is not durable, as it falls to pieces a few hours after it has cooled.

Neuman's Blowpipe.

I have just seen, in Mr Brande's *Philosophical Journal*, the description of a blowpipe by Mr Neuman, which appears to be the best hitherto contrived. Mr Neuman's description is as follows.

"Having frequent occasion to condense the air in cavities, I had observed with some surprise the length of time required by the air so confined to escape through such small apertures as might exist, or were purposely made into these cavities, and in conversation with Mr Brooks he suggested, that if the stream were tolerably equable, the principle which gave rise to such an effect might be followed with advantage in the construction of a blowpipe, and I have since verified this idea.

"The instrument I have made consists of a strong plate-copper box perfectly air-tight, three inches in width and height, and four in length, a condensing syringe to force air into the box, and a stop-cock and jet at one end of it to regulate the stream thrown out. The piston-rod of the condenser works through collars of leather in the cap, which has an aperture in the side, and a screw connected with a stop-cock, which may again communicate with a jar, bladder, or gazometer containing oxygen, hydrogen, or other gases. This communication being made, and the condenser being worked, any air that is required may be thrown into the box and propelled through the jet on the flame.

The use of the instrument is very simple. By a few strokes of the piston the air is thrown into the chamber and forms a compressed atmosphere within. When the cock

cock is opened, the air expanding issues out with great force in a small but rapid stream, which, when directed on the flame of a lamp, acts as the jet from a common blow-pipe, but with more precision and regularity. The force of the stream of air is easily adjusted by opening more or less the small stop-cock, and I have found that with a moderate charge it will remain uniform for twenty minutes; opening the stop cock, or the use of the syringe, will immediately raise it to its first strength.

"These blowpipes are very portable, not liable to injury, and answer, I believe, the expectations of all who have tried them, and I have made many of them for different persons. The whole instrument, with a lamp adapted to it, packs up in a small box not more than six inches in length and four inches in width and height, and there is space enough left for other small articles. I have fitted up boxes rather larger in size with a selection of tests and other useful articles in addition to the blowpipe, and in this state they form complete mineralogical travelling cabinets."

PHYSICAL

PHYSICAL CHARACTERS

OF

MINERALS.

PHYSICAL CHARACTERS

OF

MINERALS.

PHYSICAL CHARACTERS, are those derived from physical enomena, originating from the mutual action of mine- s and other bodies They are highly curious in a ge- 'al view, but are seldom useful in the discrimination of nerals, as they occur in but few species; and in these e cases the same physical properties are met with in y different species. The principal physical characters ich occur among minerals, are Electricity, Magnetism, l Phosphorescence.

I. *Electricity.*

It is well known that there are two kinds of electrici- ; the one named *positive* or *vitreous*, and the other *ne- tive* or *resinous*.

Electricity can be excited in minerals in three differ- : ways,—by friction, by heating, or by communica- n with an electrified body. The greater number of nerals which are capable of becoming electrical, acquire

 this

this property by friction. Earthy, saline, and metallic minerals, in this way become positively electrified; whereas, inflammable minerals became negatively electrified. Some minerals by this process become very easily and powerfully electric, while others become electric with difficulty, and exhibit but faint traces of it. A few minerals become electrical by heating, and these belong to the number that also exhibit electrical properties by friction. It has been ascertained, that these minerals have at least two points, of which the one is the seat of positive, and the other that of negative electricity. To these points, which are always placed in two opposite parts of the mineral, Hauy gives the name of *electric poles*. In order to distinguish these poles from each other, the following simple apparatus, figured in Plate VII. is employed. It consists of a needle of silver or copper, having at each end two small balls, *a*, *b*. This needle, like the common compass-needle, is moveable upon a pivot, or stem, having a very fine point, and at the bottom a broad base or foot. This stem with the needle, are insulated by placing them upon a cylindrical support of resin. To use this apparatus, we place a finger of the left hand on the foot or base of the upright stem, and taking into the right hand a stick of sealing-wax which has been rubbed, present it, during a second or two, at a small distance from the stem; this being done, we withdraw first the finger, and afterwards the stick. In this way, the needle will be found positively electrified, in such a manner that, according as we approach to one of the balls, the negative or the positive pole of a crystal become electric by heat, the ball will be attracted or repelled. The electricity of the needle will be preserved a quarter of an hour or longer, and we may, while generating it, render it either

ery sensible or very weak, by varying the distance
en the stem and the stick of sealing-wax.

urmaline is the mineral in which the property of
ing electric by heat was first observed. It crystal-
n prisms, which are frequently nine-sided, and acu-
ed with three, six or more planes. At the ordinary
rature of the atmosphere it becomes electric by
n, and the electricity which it thus acquires is al-
positive or vitreous; when two tourmalines are
d against each other, the one is electrified positive-
d the other negatively. But if the tourmaline is
l, it becomes electric; and if its two ends be after-
approached alternately to the little ball, we shall
e, that the one attracts, and the other repels the
rom which we may ascertain the poles wherein the
tive electricities reside. If one of the poles of the
aline be held near light bodies, such as grains of
or saw-dust, these minute bodies will be attracted
stone, and sometimes repelled as soon as they have
d it. When two tourmalines are presented to one
r, so that the two positive or the two negative
are towards each other, they will mutually attract
other; but if two opposite poles are presented to
nother, they will mutually repel each other. In
to make this experiment with success, the two
ls should be either balanced on a fine pivot, or sus-
d by a delicate fibre, or, what is the simplest me-
floated upon two pieces of cork. When the two
alines are heated, tie one of them upon a flat piece
k, and present to one of its poles the two poles of
r tourmaline in succession. When two similar
are towards each other, the floating tourmaline will
ound and present the opposite pole; and when two
opposite

opposite poles are presented to each other, the floating tourmaline will follow the other in all its motions, just like a floating-needle guided by the action of a magnet.

Tourmaline exhibits electrical properties by exposure to heats from 99½° to 212° of Fahrenheit. When, however, it is more and more heated, there is a term when it ceases to exhibit signs of electricity. It often happens, that after withdrawing it from the fire, we are obliged to leave it to return to a moderate temperature before it exhibits any action upon light bodies presented to it. "It would seem, (says Hauy,) that beyond the term where its electricity has become insensible through the action of too strong a heat, there is another where its effects are reproduced in an inverse sense. We have caused the foci of two burning-glasses to fall upon the extremities of a tourmaline, and have observed that each pole, after having acquired its ordinary electricity, would next cease to act, and, lastly, would pass to the opposite state; so that the attraction, after having become zero, would give place to repulsion, or reciprocally."

If a tourmaline be broken when in a state of excitation by heat, each fragment, however small it may be, has two opposite poles,—a phenomenon analogous to what takes place in a broken magnet.

In the tourmaline, the electric density diminishes rapidly from the summits or poles towards the middle of the crystal, and is almost nothing throughout a sensible space towards the middle of the prism. The greatest density which resides in the positive and negative poles, is near the summits. This distribution is analogous to that of the electric fluid diffused about a cylinder. It

may

be rendered perceptible to a certain degree, by g a tourmaline backwards and forwards, that has its planes opposite one of the balls of the little ; we shall observe, that this ball has a marked ten- towards one point of the mineral; but when the points to the middle of the prism, so that it is stant from the two poles, the needle will have no n except a mere fluttering given to the ball.

ɔy has ascertained, that the polarity which the aline and other minerals receive from heat, is rela- the form of their secondary crystals. The oppo- nd corresponding ends of crystals are generally si- both with regard to the number, to the disposition, ne figure of their planes. The forms of crystals, 'er, that become electrical by a change of tempera- deviate from this symmetry of form; so that the or parts of the crystal where the opposite electri- are situated, although they are similarly situated at wo extremities of the secondary crystal, yet dif- their configuration; one of them undergoing de- nts which are evanescent on the opposite end, or to decrements correspond that are subjected to ano- aw,—a circumstance which may enable an observer dict beforehand, simply from the inspection of the d, on which side either species of electricity will be , when the crystal shall be submitted to the test of iment. Thus, in the variety of tourmaline called e, which is a nine-sided prism acuminated on one nity with three planes, and on the other with six , experiments prove, that the first summit is the of resinous electricity, while the second manifests us electricity.

The

The same deviation from the rules of symmetry in the secondary form of crystals, has been observed in the octosexdecimal topaz.

But of all the crystals that exhibit this co-relation between the exterior configuration, and the electric agency, the most remarkable are those which appertain to the boracite, whose form is, generally, that of a cube truncated on all its edges, and also on the angles. Here the two electricities act according to the direction of four axes, each of which passes through two opposite solid angles of the cube, which is the primitive form. In one of the varieties named *defective boracite*, one of the two solid angles situated at the extremities of the same axis, is entire; the other is truncated. Now negative or resinous electricity is evinced at the angle which has not undergone any alteration; and positive or vitreous electricity at the truncated angle; thus making eight electric poles, four for each species of electricity.

"We may now ask," says Hauy, "whether, in the midst of the imposing apparatus of our artificial machines, and of that diversity of phenomena which it presents to the astonished eye, there is any thing more calculated to excite the interest of philosophers, than these little electrical instruments executed by crystallisation, than this combination of distinct and contrary actions, confined within a crystal whose greatest dimension is probably less than the twelfth of an inch? And here the observation we have so often previously made recurs to the mind with additional force, that those productions of nature which seem desirous to conceal themselves from our notice, are they which may reward us most liberally

for

for a closer examination." HAUY's *Natural Philosophy*, from p. 425 to 435, vol. i.

The third mode of exciting electricity in minerals, or that by communication, occurs only in minerals which are in a pure metallic state.

II. *Magnetism.*

Very few minerals are magnetic; it is a character which occurs principally in ores of iron, or in such minerals as contain a portion of metallic iron, or iron in the state of black oxide.

A good many minerals, after exposure to the blowpipe, become magnetical.

III. *Phosphorescence.*

Some minerals, when rubbed or heated, emit in the dark a more or less shining light, or are said to be phosphorescent. Thus, yellow blende, when scratched with a hard body, emits a strong light. When two pieces of quartz are forcibly struck against each other, both become luminous; and fluor-spar, when heated, becomes phosphorescent.

GEOGNOSTICAL AND GEOGRAPHIC/ CHARACTERS.

These characters do not require any particular ration.

FINIS.

THE PRIMITIVE FORMS.

Fig. 27.

Rhomboidal base.

Tetrahedron.
Fig. 28.

Regular six sided. Prism
Fig. 29.

Rhomboidal Dodecahedron.
Fig. 30.

Fig. 33.

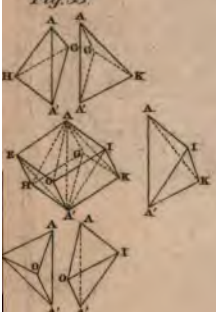


Fig. 34.

Fig. 35.

Fig. 38.

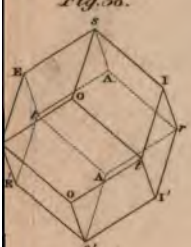


Fig. 39.

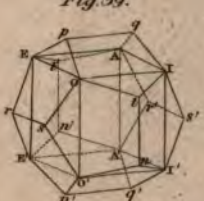


Fig. 40.

PLATE V.

Fig. 44.

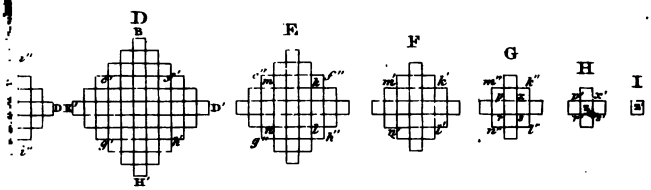


Fig. 50.

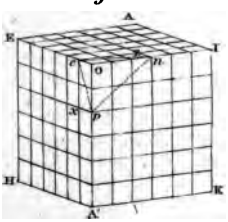


Fig. 49.

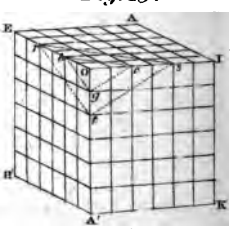
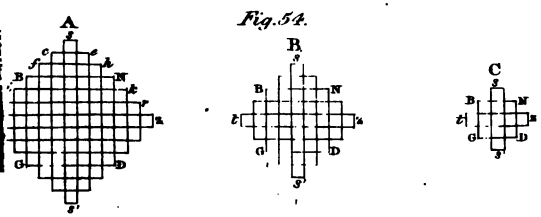


Fig. 54.



F. Mitchell sculp.